INSTRUCTION MANUAL

MODEL 110

FUNCTION GENERATOR

and

MODEL 111

VOLTAGE CONTROLLED GENERATOR

WAVETEK

8159 ENGINEER ROAD, SAN DIEGO, CALIFORNIA

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Revised 1-68

Model 110 and 110B Function Generator

Model 111, VGG Voltage Controlled Generator

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WARRANTY

WAVETEK warrants instruments manufactured by it to have met WAVETEK's published specifications at the time of shipment of such instruments, and agrees to repair within one year of shipment, such instruments or their components (excluding batteries), which under normal use are found to be defective as a result of our manufacturing. Our obligation under this warranty is limited solely to repairing any such instrument which in our sole opinion proves to be defective when returned to our factory. Transportation to the factory is to be prepaid by the purchaser. Instruments returned to the factory will be accepted only when prior authorization has been given by a representative of WAVETEK.

This warranty does not apply to any of our products which have been repaired or altered by persons not authorized by us, or not in accordance with instructions furnished by us. If the instrument is defective as a result of misuse, improper repair, or abnormal conditions or operations, repairs will be billed at cost.

WAVETEK assumes no responsibility for its product being used in a hazardous or dangerous manner either alone or in conjunction with other equipment. WAVETEK assumes no liability for secondary charges or consequential damages, and in any event, WAVETEK's liability for breach of warranty under any contract or otherwise, shall not exceed the purchase price of the specific instrument shipped and as to which a claim is made.

Any recommendations made by WAVETEK for the use of its products are based upon tests believed to be reliable, but WAVETEK makes no warranty of the results to be obtained. This warranty is in lieu of all other warranties, expressed or implied, and no representative or person is authorized to represent or assume for us any liability in connection with the sale of our products other than set forth herein.

SECTION I
GENERAL DESCRIPTION AND OPERATION

GENERAL

The WAVETEK Model 110 Function Generator and Model 111 Voltage Controlled Generator (VCG) are semi-precision sources of waveforms from servo to video frequencies. These units are extremely rugged, completely transistorized portable packages. They feature complete plug-in printed circuit board construction with interchangeable individually calibrated printed circuit boards utilizing silicon semiconductors throughout. The extremely clean and stable waveform signal from 0.005 Hz to 1 MHz (Model 110) and 0.0015 Hz to 1 MHz (Model 111) make these generators highly versatile general purpose pieces of equipment for the laboratory or the field.

The Models 110 and 111 are identical in size and performance except that the Model 111 offers VCG and the additional ramp function. Both Models feature a main output with function selector switch and amplitude attenuator. In addition, they offer simultaneous 5 volt peak to peak 50Ω outputs of sine, square and triangle waveforms; 1 volt, 10 nsec. rise and fall time square wave; and, -10 volt sync pulse. Frequency is controlled by an eight position range switch at 20:1 range, thus providing good overlap.

All outputs may be shorted simultaneously and the generator will continue to oscillate internally with less than 0.5% change in frequency. Voltage may be applied back into the generator so long as this voltage does not exceed the maximum output voltage. Up to ±50 volts may be applied to the VCG input without damage.

MODEL 111

The Model 111 features VCG voltage control of frequency by the internal frequency dial operating in parallel with the VCG input terminals. The generated frequency is the resultant sum of the VCG input voltage and the dial setting. Without an externally applied voltage, the dial governs and the generator operates like a Model 110. By adding a positive voltage to the input terminals, the frequency is increased; by adding a negative voltage to the input terminals, the frequency is decreased. The applied voltage may be either a d-c programming voltage or an a-c frequency modulating voltage. The modulation band width is 100 KHz (it is possible to have a higher modulation frequency than carrier frequency, with a resulting triangle wave that may look like a staircase).

The frequency dial is a continuously variable quality composition potentiometer. An electronic frequency vernier is incorporated for extremely precise frequency adjustment. The vernier covers one minor dial division for one vernier rotation.

In addition to sine, square and triangle, the Model 111 also offers ramp functions. The base line of this ramp signal is zero volts and the ramp duty cycle is 50 per cent. The ramp on the binding post is a positive ramp; the ramp on the BNC connector is a negative ramp.

MODELS 110 and 111; MODELS 110B and 111B

The Models 110 and 111 incorporate a power amplifier which offers a maximum of 32.5 volts peak to peak (+16.25 volts ramp) at the binding post output. An attenuator is included on the input of this output amplifier. The amplifier will supply 30 volts peak to peak (15 volts ramp) into a 600Ω load at maximum output setting. Ten volts peak to peak (5 volts ramp) may be driven into a 50Ω load with undistorted waveforms by rotating the output attenuator counterclockwise until clipping stops.

NOTE

When a relatively small output signal is needed, it is recommended that the output be attenuated by an external pair of resistors to a level approximating that required and the internal attenuator be used as the amplitude vernier. Attenuating the output by 10:1, 100:1, or 1000:1, etc., the use of a pair of external resistors will insure clean waveform quality and good resolution by the internal attenuator in low level applications.

The output amplifier inverts the signals appearing at the BNC connectors. Thus there will be a 180 degree phase shift between the sine, square or triangle output appearing on the binding posts and those on the BNC's. The ramp on the binding post will be simultaneous in time with the ramp on the BNC; however, it is a positive ramp while the BNC is a negative ramp. Both have a base line very near zero volts.

The Models 110B and 111B incorporate an internal battery charger in place of the power amplifier. These units will operate continuously for eight hours (Model 110B) or six hours (Model 111B) from the internal batteries. Both may be charged completely in 16 hours. The charge is designed so that charging occurs while the unit is in operation. A screwdriver adjustment enables the operator to set the desired charge rate. In maximum clockwise position, charge time from discharge to charge is 14 hours. Frequent operation with the instrument plugged into a-c power with the charge rate set this high would result in damage to the batteries. Maximum counterclockwise position of the rear control sets the charge rate to maintain the

batteries at full charge without overcharge. The units are wired so that when plugged into a-c power but turned OFF, a trickle charge maintains the batteries at full charge setting.

The power amplifier used in the Models 110 and 111 is not utilized in the Models 110B and 111B, and is thus bypassed. The signal appearing on the binding post is now a maximum 5 volts peak to peak (-2.5 volts ramp) at approximately 600Ω output impedance. Because no inverting amplifier is used, output signals on the binding post are directly in phase with those on the BNC's.

MODELS 110 and 110B; CONTROLS AND TERMINALS

Controls and outputs for the Models 110 and 110B are identical except for output impedances and voltage levels at the binding posts. For the Model 110, these are 50Ω and 0 to 32.5 volts peak to peak (or, by removal of one jumper, an impedance of 600Ω is obtained). Output impedance of the Model 110B is 600Ω at voltage levels of 0 to 5 volts peak to peak. No zero adjustment is provided for this output on the Model 110B, but internal controls permit setting the balance of each function independently.

Power Switch

The power switch on the Model 110 connects the instrument to either 115 VAC or 230 VAC line power through a 3/4 ampere fuse mounted on the rear panel. (See drawing in Schematic Section of this manual for 115 VAC and 230 VAC connections.)

For the Model 110B, when the power switch is OFF, the batteries are disconnected from the instrument but connected to the charger. The charger is set for a trickle-charge of approximately 3 ma if it is plugged into the power line. In the ON position, the batteries are connected to the instrument for normal operation. If the instrument is not connected to line power, the batteries are discharging; but, if connected, the charger supplies sufficient current to operate the instrument and charge the batteries. The amount of charge current is dependent upon the potentiometer available through the rear panel. In maximum clockwise rotation the charge current is approximately 50 ma. In maximum counter-clockwise rotation the charge current is approximately 15 ma. The 15 ma charge current is recommended for optimum battery life unless a greater charge rate is required by duty use cycle.

CAUTION

If the batteries are allowed to completely discharge, the instrument power supply cannot provide adequate power to simultaneously operate and charge. If this condition exists, the

instrument should be allowed to recharge for at least one hour before it is used in the a-c mode.

Frequency Range Switch

An eight position switch which selects the appropriate timing resistor and capacitor for proper frequency range and selects appropriate compensating resistors for constant dial potentiometer loading, and balanced integrator source resistances.

Frequency Dial

A continuously variable high quality composition potentiometer which allows precise frequency adjustment. The generated frequency is the product of the dial setting and the frequency range switch multiplier; for instance, if the dial setting is 3 and 1/2, and the "Freq Hz" dial is at X100, the frequency generated is 350 Hz.

Selector Switch, Output Attenuator, and D-C Zero Control (rear-mounted screwdriver adjustment)

Output impedance is 50Ω, but output is current limited to drive approximately ±100 ma into a short circuit. Output at maximum clockwise attenuator position is 32.5 volts peak to peak open circuit, and 30 volts peak to peak into 600Ω load. For load impedance less than 600Ω, the attenuator must be rotated counter-clockwise or clipping will result. Maximum undistorted output into a 50Ω load is 10 volts peak to peak.

The output attenuator covers a 30 db range. For output voltages less than 20 db below maximum output, it is recommended that an external attenuator using a pair of resistors be used and the internal attenuator be used for fine control. For a 10:1 attenuator, use a 470Ω resistor in series in a 50Ω shunt with the load. For a 100:1 attenuator, use 1K in series and 10Ω in shunt, or 4.7K in series and 51Ω in shunt (these values are indicative and not critical). The attenuator is located in the input/output amplifier. As a result, the zero adjust will be most critical at minimum setting. The rear-mounted d-c adjustment control should be adjusted with the attenuator in maximum counter-clockwise position.

NOTE

Zero adjust control is a high resolution Zero Adjust Potentiometer not a d-c offset control.

Switch selected sine, square, and triangle waves will have equal peak to peak amplitude for all attenuator settings.

The 5 Volt Triangle, 5 Volt Sine and 5 Volt Square Outputs

These outputs are accurate 5 volt, 50Ω sources balanced about ground. They will drive 2.5 volts peak to peak into a 50Ω load, and supply ±50 ma peak into a short circuit.

The 10 Nsec Square Output

The 10 nsec square output is approximately 1 volt peak to peak open circuit, 0.5 volts peak to peak into a 50Ω load with better than 10 nsec rise and fall time. Always use a 50Ω cable and a 50Ω termination when using this output.

Sync Output

At least -10 volts sync signal of typical 1.5 μsec. pulse width. The pulse occurs once per cycle coincident with positive transition of the 5 volt square wave, and a positive peak of sine and triangle waves.

NOTE

> Due to its very narrow pulse width, the sync pulse is difficult to observe at low frequencies. However, it will trigger wide band scopes such as the Tektronix Model 453 at all frequencies.

MODELS 111 AND 111B; CONTROLS AND TERMINALS

Power/Dial Multiplier Switch

This switch incorporates two ON positions, X.3 and X1. This switch, in conjunction with the frequency range switch and the frequency dial, determines the generated frequency. For example, the dial is set a 3 and 1/2, the frequency range switch setting is X100, and the dial multiplier switch at X1, the frequency generated is 350 Hz. With the dial multiplier switch at X.3, the frequency is 105 Hz.

In the Model 111B, when the switch is in the OFF position, the batteries are disconnected from the instrument but connected to the charger. The charger is set for a trickle-charge of approximately 3 ma when the instrument is connected to line power. In the ON position, the batteries are connected to the instrument for normal operation. If the instrument is not connected to the line power, the batteries are discharging; if connected, the charger supplies sufficient current to operate the instrument and charge the batteries. The amount of charge current available is variable through the potentiometer at the rear panel. In maximum counter-clockwise rotation the charge current is approximately 15 ma. The 15 ma charge current is recommended for optimum battery life unless the maximum charge rate is required.

CAUTION

If the batteries are allowed to completely discharge, the instrument power supply cannot provide adequate power to simultaneously operate and charge. If this condition exists, the instrument should be allowed to recharge for at least one hour before it is used in the a-c mode.

Frequency Range Switch

The frequency range switch selects the appropriate timing resistor and capacitor for proper frequency range.

Frequency Dial and Frequency Vernier

The frequency dial is a high quality composition potentiometer providing continuous frequency control. In addition, an electronic vernier control is provided for precise frequency setting. Complete rotation of the vernier changes the frequency approximately one minor dial division for all settings of the dial. The frequency vernier should be in extreme clockwise position (cal) for maximum dial accuracy.

The VCG Input

The VCG input permits remote control of dial frequency and frequency modulation. The calibration factor is 0.5 volts per major dial division. A positive voltage causes an increase in frequency and a negative voltage causes a decrease. The setting of the frequency dial (and the frequency vernier) determines base frequency. The VCG input impedance is 10 KΩ. Up to ±50 volts can be applied to the VCG input without damage.

The 5 Volt Triangle, 5 Volt Sine and 5 Volt Square Outputs

These outputs are accurate 5 volt, 50Ω sources that are balanced about ground. They will drive 2.5 volts peak to peak into a 50Ω load, and supply ±50 ma peak into a short circuit. The ramp output is 2.5 volts. Fixed ramp output is identical with fixed sine, square, and triangle output except that the base line is at zero volt ±25 mv (5 mv typical). Open circuit voltage is a 2.5 volt negative going ramp. Ramp duty cycle is 50%. Negative ramp coincides in time with the negative going portion of the triangle wave and the positive half of the square wave. The ramp signal passing through the output amplifier is amplified and inverted so that the resultant ramp appearing at the binding posts runs from zero to a positive voltage.

Model 111B; Main Output

Because no inverting amplifier is utilized, output waveforms in the switch-selected output are in phase with fixed outputs. Maximum output is 5 volts peak to peak with 600Ω output impedance and -2.5 volts ramp.

SECTION II
SPECIFICATIONS AND TEST PROCEDURES

This section contains specifications for the WAVETEK instruments discussed in this manual and procedures for testing their accuracy. Table 2-1 provides specifications for the Models 110 and 110B Function Generators, and Table 2-2 provides specifications for the Models 111 and 111B Voltage Controlled Generators.

NOTE

Specifications apply 10% to 100% of maximum amplitude setting.

VERSATILITY

Waveforms

Sine ∿, square ⊓, triangle △ and sync pulse.

Dynamic Frequency

0.005 Hz to 1 MHz (3.3 min. to 1 μsec).

NOTE: Dial is a high quality composition potentiometer allowing true continuously variable frequency control.

Ranges

X.01 = 0.005 Hz to 0.1 Hz.

X0.1 = 0.05 Hz to 1 Hz.

X1.0 = 0.5 Hz to 10 Hz.

X10 = 5 Hz to 100 Hz.

X100 = 50 Hz to 1 KHz.

X1K = 500 Hz to 10 KHz.

X10K = 5 KHz to 100 KHz.

X100K = 50 KHz to 1 MHz.

Table 2-1. Models 110 and 110B Specifications
Sheet 1 of 5

Six Simultaneous Outputs:

1) ∿, ⊓ or ∿ selectable.

Amplitude adjustable over at least a 50:1 range.

Output impedance 50Ω (600Ω output impedance available by removing one jumper wire).

At least 30 volts peak to peak into an open circuit.

At least 10 volts peak to peak into a 50Ω load (the attenuator should be adjusted counter-clockwise until clipping stops).

Short circuit current ±100 ma.

Model 110B: A maximum of 5 volts peak to peak at 600Ω output impedance.

2) 50Ω ⊓ 0.5 volt peak to peak, 10 nsec. risetime into 50Ω.

3) 50Ω ⊓ 5 volts peak to peak, 15 nsec. risetime.

4) 50Ω ∿ 5 volts peak to peak.

5) 50Ω ∿ 5 volts peak to peak.

6) Sync pulse: At least -10 volts into open circuit; less than 5 μsec. duration.

NOTE: All outputs may be shorted to signal ground without damage to the instrument.

HORIZONTAL PRECISION

Dial Accuracy

±1% of full scale 0.005 Hz to 100 KHz.

±2% of full scale 100 KHz to 1 MHz.

Frequency Stability

Short term: Drift less than ±0.05% of setting for 10 minutes.

Table 2-1. Models 110 and 110B Specifications.
Sheet 2 of 5

Long term: Drift less than ±0.25% of setting for 24 hours.

No critical components requiring internal oven.

Jitter

±0.025% cycle to cycle stability.

VERTICAL PRECISION

Frequency Response

Amplitude change with frequency less than 0.1 db 0.005 Hz to 10 KHz, 0.2 db 10 KHz to 100 KHz, 0.5 db 100 KHz to 1 MHz.

Peak to Peak Voltage Accuracy

±1% for 5-volt outputs.

±1% for 30-volt output into a 600Ω load at maximum gain.

±10% for 0.5-volt output into 50Ω.

Amplitude Stability

Short term: ±0.05% of maximum peak to peak values for 10 minutes.

Long term: ±0.25% of maximum peak to peak values for 24 hours.

Symmetry

All waveforms are symmetrical about ground within ±1% of maximum peak to peak amplitude (external zero adjust rear-panel control provided for output number 1).

D-C Offset Stability

Short term: ±0.05% of maximum peak to peak amplitude for 10 minutes.

Long term: ±0.25% of maximum peak to peak amplitude for 24 hours.

Table 2-1. Models 110 and 110B Specifications
Sheet 3 of 5

PURITY

Sine Wave Distortion

Less than:	0.5%	0.005 Hz to 10 KHz.
	1.0%	10 KHz to 100 KHz.
	2.0%	100 KHz to 1 MHz.

Triangle Linearity

Greater than:	99%	0.005 Hz to 100 KHz.
	95%	100 KHz to 1 MHz.

Square Wave Rise and Fall Time

0.5-volt output less than 10 nsec. into 50Ω termination.

5-volt output less than 15 nsec.

30-volt output less than 100 nsec.

5-volt adjustable (Model 110B) less than 100 nsec.

Total Aberrations

Less than 5% (overshoot, preshoot, etc.).

Tilt

Less than 0.5%.

Time Symmetry

All waveforms:	99%	0.005 Hz to 100 KHz.
	98%	100 KHz to 1 MHz.

ENVIRONMENTAL

Temperature

All specifications listed, except stability, are for 25°C ± 5°C.

Table 2-1. Models 110 and 110B Specifications
Sheet 4 of 5

For operation from 0°C to 55°C, derate all specifications by a factor of 2.

MECHANICAL

Dimensions

7 and 3/4 inches wide, 5 and 1/4 inches high, 7 and 1/2 inches deep.

Weight

7 pounds net, 10 pounds shipping.

Color

Clear anodized aluminum.

Controls

ON-OFF power switch, frequency range switch, frequency dial, function selector switch, amplitude attenuator, d-c zero adjustment (rear). All-silicon semiconductors, modular plug-in construction.

Power

Model 110: 105 volts to 125 volts or 200 volts to 250 volts, 50 Hz to 400 Hz. Less than 10 watts.

Model 110B: D-C rechargeable ni-cad batteries provided with built-in charger. Eight hours of operation on batteries for every 16 hours of charge; simultaneous operation and charge.

105 volts to 125 volts or 200 volts to 250 volts 50 Hz to 400 Hz. Less than 10 watts.

Table 2-1. Models 110 and 110B Specifications
Sheet 5 of 5

VERSATILITY

Waveforms

Sine ∿, square ⊓, triangle ∿, ramp ◿ and sync pulse.

Dynamic Frequency

0.0015 Hz to 1 MHz (10 min. to 1 μsec).

Ranges

X.01 = 0.005 Hz to 0.1 Hz.

X0.1 = 0.05 Hz to 1 Hz.

X1.0 = 0.5 Hz to 10 Hz.

X10 = 5 Hz to 100 Hz.

X100 = 50 Hz to 1 KHz.

X1K = 500 Hz to 10 KHz.

X10K = 5 KHz to 100 KHz.

X100K = 50 KHz to 1 MHz.

X.003 = 0.0015 Hz to 0.03 Hz.

X.03 = 0.015 Hz to 0.3 Hz.

X.3 = 0.15 Hz to 3 Hz.

X3.0 = 1.5 Hz to 30 Hz.

X30 = 15 Hz to 300 Hz.

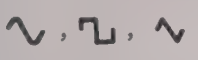
X300 = 150 Hz to 3 KHz.

X3K = 1.5 KHz to 30 KHz.

X30K = 15 KHz to 300 KHz.

Table 2-2. Models 111 and 111B Specifications
Sheet 1 of 6

Seven Simultaneous Outputs:

1)  selectable.

Amplitude adjustable over at least a 50:1 range.

Output impedance 50Ω (600Ω output impedance available by removing one jumper wire).

At least 30 volts peak to peak (15 volts ramp) into an open circuit.

At least 10 volts peak to peak (5 volts ramp) into a 50Ω load (the attenuator should be adjusted counter-clockwise until clipping stops).

Short circuit current ±100 ma.

Model 111B: A maximum of 5 volts peak to peak at 600Ω output impedance (2.5 volts ramp).

2) 50Ω 0.5 volt peak to peak, 10 nsec. risetime into 50Ω.

3) 50Ω 5 volts peak to peak, 15 nsec. risetime.

4) 50Ω 5 volts peak to peak.

5) 50Ω 5 volts peak to peak.

6) 50Ω 0 volts to -2.5 volts ramp; 50% duty cycle.

7) Sync pulse: At least -10 volts into open circuit; less than 5 μsec. duration.

NOTE: All outputs may be shorted to signal ground without damage to the instrument.

VCG - Voltage Controlled Generator

Over 20:1 frequency ratio (selectable in ranges of 3:1 allowing excellent range overlap). 4.75 volts input for 20:1 frequency ratio (0.5 volts ±1% per Major dial divison). Input impedance 10K.

Table 2-2. Models 111 and 111B Specifications
Sheet 2 of 6

HORIZONTAL PRECISION

Dial Accuracy

±1% of full scale 0.0015 Hz to 100 KHz.

±2% of full scale 100 KHz to 1 MHz.

NOTE: Dial is a high quality composition potentiometer allowing true continuously variable frequency control.

Electronic Frequency Vernier

One turn for approximately one minor dial division.

VCG Linearity

±0.1% frequency versus input voltage (frequency error ±0.1% of total frequency deviation - best straight line method). 0.0015 Hz to 100 KHz generated frequency. From 10% to 100% of maximum dial frequency.

VCG Bandwidth

100 KHz.

Frequency Stability

Short term: Drift less than ±0.05% of setting for 10 minutes.

Long term: Drift less than ±0.25% of setting for 24 hours.

No critical components requiring internal oven.

Jitter

±0.025% cycle to cycle stability.

VERTICAL PRECISION

Frequency Response

Amplitude change with frequency less than 0.1 db 0.0015 Hz to 10 KHz, 0.2 db 10 KHz to 100 KHz, 0.5 db 100 KHz to 1 MHz.

Table 2-2. Models 111 and 111B Specifications
Sheet 3 of 6

Peak to Peak Voltage Accuracy

±1% for 5-volt and 2.5-volt outputs.

±1% for 30-volt output into a 600Ω load at maximum gain.

±10% for 0.5-volt output.

Amplitude Stability

Short term: ±0.05% of maximum peak to peak values for 10 minutes.

Long term: ±0.25% of maximum peak to peak values for 24 hours.

Symmetry

All waveforms, except ramp, are symmetrical about ground within ±1% of maximum peak to peak amplitude (external zero adjust rear-panel control provided for output number 1).

DC Offset Stability

Short term: ±0.05% of maximum peak to peak amplitude for 10 minutes.

Long term: ±0.25% of maximum peak to peak amplitude for 24 hours.

PURITY

Sine Wave Distortion

Less than:	0.5%	0.0015Hz to 10KHz.
	1.0%	10KHz to 100KHz.
	2.0%	100KHz to 600KHz.
	3.0%	600KHz to 1MHz.

Triangle and Ramp Linearity

Greater than:	99%	0.0015Hz to 100KHz.
	95%	100KHz to 1MHz.

Ramp Fall Time

Less than 200 nsec.

Square Wave Rise and Fall Time

0.5-volt output less than 10 nsec into 50Ω termination.

5-volt output less than 15 nsec.

30-volt output less than 100 nsec.

5-volt adjustable (Model 111B) less than 100 nsec.

Total Aberrations

Less than 5% (overshoot, preshoot, etc.) when properly terminated.

Tilt

Less than 0.5%

Time Symmetry

All Waveforms:	99%	0.0015 Hz to 100 KHz.
	98%	100 KHz to 1 MHz.

ENVIRONMENTAL

Temperature

All specifications listed, except stability, are for 25°C ± 5°C.

For operation from 0°C to 55°C, derate all specifications by a factor of 2.

MECHANICAL

Dimensions

7 and 1/4 inches wide, 5 and 1/4 inches high, 7 and 1/2 inches deep.

Table 2-2. Models 111 and 111B Specifications

Weight

7 pounds net, 10 pounds shipping.

Color

Clear anodized aluminum.

Controls

OFF X.3-X1 power/dial multiplier switch, frequency range switch, frequency dial, frequency vernier, function selector switch, amplitude attenuator, d-c zero adjustment (rear).

All-silicon semiconductors, modular plug-in construction.

Power

Model 111: 105 volts to 125 volts or 200 volts to 250 volts, 50 Hz to 400 Hz. Less than 10 watts.

Model 111B: D-C rechargeable ni-cad batteries provided with built-in charger. Six hours of operation on batteries for every 16 hours of charge; simultaneous operation and charge. 105 volts to 125 volts or 200 volts to 250 volts, 50 Hz to 400 Hz. Less than 10 watts.

NOTE

The covers of these instruments may be mounted flush with the front panel by removing the cover and replacing it using the alternate set of tapped holes in the spacer bars.

Table 2-2. Models 111 and 111B Specifications
Sheet 6 of 6

TEST PROCEDURES

GENERAL INFORMATION

Specifications apply only when the dial setting is between 0.5 and 10. Instruments should be within specifications within 30 minutes' warm-up time. All specifications are for 25°C ± 5°C and 105 to 125 volts a-c, 50 Hz to 400 Hz. All measurements must be made as described herein. Frequency stability specifications refer to constant temperature, line voltage, panel setting, and loads; testing must be made after one hour warm-up at defined conditions.

TESTING INFORMATION

All frequency measurements should be made with the function selector switch on sine ∿, output attenuator set in the maximum counter-clockwise most position, all outputs unconnected (and VCG input, Model 111) except the 10 nsec. square wave output which should be connected to a counter through a 50Ω cable using 50Ω termination at the counter. The frequency vernier (Model 111) should be at maximum clockwise position (cal). The generated frequency should be within specifications for all combinations of the range switch and frequency dial.

Time symmetry measurements should be made using this setup and by measuring the positive and negative half cycles of the square wave. The two half cycle measurements should differ by no more than 1% of the total one cycle measurement.

Cycle-to-cycle jitter measurements should be made with this same setup. An oscilloscope with a delaying sweep or frequency counter may be used for cycle-to-cycle time jitter measurement.

VCG linearity should be made by again using the same setup as above, with the addition of a low impedance (50Ω maximum) source connected to the VCG input.

VCG input voltage should be measured with a high accuracy voltmeter such as DVM or a differential voltmeter.

OTHER KINDS OF TESTS

All voltage measurements should be made with an accurate wide band peak measuring device. It is strongly suggested that a Tektronix type W, or type Z plug-in with an appropriate oscilloscope be used for making these voltage measurements. The measuring device should have at least 50KΩ input impedance and sufficient band width so that waveform peaks are accurately

measurable. The measurements should be made individually with no loads connected to the instrument.

When making very accurate peak measurements, minor aberrations will be noted on the waveform due to the switching of the square wave. The peak value is that voltage which appears immediately prior to these minor aberrations. Accurate peak waveform measurements shold be made a +1KHz with the dial set at 10. Accurate high frequency measurements are difficult to make and require considerable care in lead connection, current, and cable termination.

Lack of symmetry is defined as the difference in the plus and minus peak voltages. For example: a 5 volt signal with 1% dis-symmetry could read +2.525 volts and -2.475 volts.

All fixed outputs should be measured individually with the function switch on sine ∿ , and the amplitude attenuator in maximum counter-clockwise position. The switch selectable output should be measured with the attenuator in maximum clockwise position and the appropriate function selected. Nothing should be connected to the binding posts when making this measurement.

When measuring the selectable output amplitude of the Models 110B and 111B, the measuring device should have at least 500K input impedance. It should be terminated into 600Ω for high frequency measurements. Sine distortion, triangle and ramp linearity, rise and fall time, total aberrations and tilt specifications should be made independently connecting only one output to the appropriate measuring device at a time.

BNC outputs (except sync) should be connected to the measuring device with a 50Ω cable properly terminated for making all high frequency measurements.

The output amplifier, in Models 110 through Model 116, may have a tendency to oscillate when operating in the 100KHz to 1 MHz range into a cable terminated in an open circuit (very high impedance). Oscillation, when it occurs, is due to reflections back into the output amplifier and so, may be affected by signal level and cable length.

GENERAL NOTE

The Test Procedures very specifically define individually making measurements without simultaneous load of the various connectors. Simultaneous loading of all outputs will have only a minor effect on the frequency amplitude and purity performance.

SECTION III
THEORY OF OPERATION

MODEL 110. Refer to the block diagram of the Model 110 Function Generator in Section VI. An understanding of the Model 111 is best accomplished by first studying the Model 110.

A square wave is generated into an integrator composed of a wide band differential d-c amplifier and integrating resistor R with integrating capacitor C. The output of the integrator is fed into the Hysteresis and output switch. The Hysteresis and output switch function like a Schmitt trigger with the limit points set wide apart. As a result they fire when the triangle wave reaches +2.5 volts and -2.5 volts. The firing of the Hysteresis and the output switches reverses the square wave fed into the integrator and the triangle wave reverses direction. The result is simultaneous generation of a square wave and triangle wave of the same frequency with the positive half cycle of the square wave coincident with the negative going portion of the triangle wave.

The frequency of oscillation is determined by the R and C selected by the frequency range switch and by the amplitude of the square wave fed into the integrating resistor R. The ±5 volt square wave is fed to the frequency dial potentiometer. Setting the potentiometer at the top of the dial results in maximum voltage and thus maximum integrating current is generated resulting in maximum frequency. Frequency is directly proportional to the square wave amplitude appearing on the arm of the frequency dial potentiometer.

The sine wave is produced by shaping the triangle wave. The triangle wave is fed into a shaping network composed of resistors and diodes with transistor emitter followers biasing circuitry. As the triangle wave voltage passes through zero, loading of the triangle wave is minimal and thus slope is maximum. As the triangle wave voltage increases successively, diodes with current limiting resistors conduct causing the slope of the output to be less. The resultant waveform resembles a sine wave but is pointed at the top. The diodes are biased by transistor emitter followers whose base emitter junctions are opposite in polarity from the diodes. This provides a first order compensation for drifts due to temperature variations.

The increase in diode current at the peak of the triangle wave causes a pointed voltage pattern on the collectors of the emitter followers. This pointed waveform is combined out of phase with the somewhat pointed sine wave. The resultant waveform is an almost pure sine wave. The circuitry is completely symmetrical about ground using PNP transistors on one side and NPN transistors on the other. The sine wave produced by shaping is considerably less in amplitude than the triangle wave input and is thus amplified to be equal to the triangle wave.

The triangle wave output of the integrator, the sine wave output, and the square wave coupled through an associated amplifier are fed to the function selector switch and also to the simultaneous BNC outputs. The switch is coupled to the attenuator which in turn drives the output power amplifier. In the Model 110B and the Model 111B, this power amplifier is replaced by a 560Ω resistor.

The entire instrument except the power amplifier, runs off a current regulated +6 volts and -6 volts. The power amplifier runs off of an unregulated ±25 volts.

MODEL 111. Refer to the block diagram of the Model 111 Voltage Controlled Generator in Section VI. In the Model 111, unique circuitry is provided whereby the amplitude of the square wave fed to the integrator is controlled by an analog voltage. The integrating resistor R is connected to a PNP and NPN transistor switch which is connected in an inverted configuration. The bases of these transistor switches are driven from the output square wave. Negative square waves cause conduction of the PNP transistor, and positive square waves cause conduction of the NPN. These transistors connected in inverted configuration when in the conduction mode, have in the vicinity of 10 mv drop between their emitter and collector.

The VCG input and the frequency dial both drive an operational amplifier whose output is proportional to, but inverted from, the sum of the input voltages. The first operational amplifier drives the second operational amplifier which is designed for unity gain, but inversion about ground. As a result, a positive voltage appearing on the input causes a negative voltage at the output of the first amplifier and a positive voltage at the output of the second amplifier. A negative square wave thus causes integrating resistor R to be shorted to the negative voltage output of the first amplifier. A positive square voltage causes resistor R to be shorted to the positive voltage output of the second amplifier.

The circuit would be complete and work accurately except for the small drop across the switching transistors. This drop is compensated for by inserting a matching transistor in the feedback loop of the operational amplifiers. The base drive to the compensating transistor is designed to equal the base drive to the switching transistors. The switching transistors and the operational amplifiers must have good high frequency characteristics since square waves up to 1 MHz must be controlled. As a result, the basic circuitry is also capable of a wide band frequency modulation.

The ramp is formed by offsetting the triangle wave so that the positive peaks are at zero d-c. This resultant waveform is shorted to ground by transistor switches during the positive going half cycle. A two-stage clipping circuit is used in order to provide a very flat base line near zero volts. The excellent linearity of the triangle wave is preserved. The high quality ramp signal

is fed through an associated amplifier to the BNC connector and the function selector switch.

CIRCUIT DESCRIPTION

Refer to the Model 110 and 111 Main Board schematic diagrams.

INTEGRATOR, MAIN BOARD

Q1 through Q10 and their associated circuitry make up the wide band d-c integrator amplifier. The "Freq Hz" switch on the front panel selects the appropriate integrating resistors and capacitors for frequency ranging.

Q1 and Q2 are a Darlington input pair for the minus input; Q 4 and Q 3 are a Darlington pair in the plus input. Transistors Q1 through Q4 are low current, high gain, wide band transistors which allow the inputs to operate with less than 40 nano amps of source current. The collectors of Q2 and Q3 work into a complex load made up of R1, R3, R4, C3, and the input impedance of Q5 and Q6. Q5 and Q6 form a differential amplifier stage driving the differential stage made up of Q7 and Q8. The output is taken off single ended at the collector of Q7 through the push-pull emitter follower, Q9 and Q10. CR1 and CR2 provide the bias voltage for Q9 and Q10 to prevent crossover distortion. R8 allows the d-c levels in the two sides of the amplifier to be balanced throughout. The triangle output is connected to pin 1. It is also fed through R22 to the sine converter and to the Hysteresis switch made up of Q25 through Q30.

HYSTERESIS AND OUTPUT SWITCH, MAIN BOARD

The transistors in the Hysteresis switch are connected to form a bi-stable switch. Either the Q25, Q26 side or the Q28, Q30 side can be on but not both at the same time. When the positive going triangle reaches the firing level set by R77, the Q26 side turns on and the Q28 side turns off. The triangle starts its negative slope and when it reaches the firing level set by R78, the Q28 side turns on and the Q26 side turns off. The Hysteresis switch is d-c coupled to the bi-stable output switch made up of Q31 through Q34. The square wave is coupled to pin 10.

The 10 volt peak to peak square wave is differentiated, amplified and clipped by Q35, R96, C25, CR15, R101, C27, and R110 to provide a -10 volt sync spike which has a duration of less than 5 μsec. The sync pulse is coupled to pin 13. The square wave is also coupled to a push-pull emitter follower made up of Q36 through Q39. R104 allows the output amplitude to be adjusted, and R99 adjusts the waveform so that it is symmetrical about ground. Diodes CR16 through CR19 provide temperature compensation. The output of the super emitter follower is a 5 volt peak to peak square wave coupled to pin 11.

SINE CONVERTER AND AMPLIFIER, MAIN BOARD

Transistors Q11 through Q18 are emitter followers in the sine converter that bias and temperature compensate the clipping diodes, CR3 through CR10. Diodes CR3, CR5, CR7, and CR9 clip the positive portion of the triangle at points set by the pots in the base of their associated emitter follower transistors. Diodes CR4, CR7, CR8, and CR10 clip the negative portion of the triangle. Therefore, the input to the sine amplifier is a sine wave with small peaks at the top and bottom. The sine wave is fed to the plus input of the sine amplifier through R64. The sine amplifier is a d-c wide band operational amplifier connected in a potentiometric configuration. R69 is the feedback resistor. The peaks on the sine wave are also seen at the collectors of the emitter followers in the sine converter. These peaks are coupled through R54 and R56 to the minus input of the sine amplifier and peak cancellation occurs in the amplifier giving a clean sine wave at the output. The sine wave is coupled to pin 9. R60 adjusts the sine wave symmetry about ground and R64 adjusts the sine wave amplitude.

POWER SUPPLY AND OUTPUT AMPLIFIER BOARD

A-c voltage is coupled from the transformer to pins 14 and 15 to drive the bridge rectifier made up of diodes CR1 through CR4. Filtering is provided by C1 and C2. Q1 is a transistor connected and operated as a zener diode providing a reference voltage for the +6 volt supply. Q2 and Q3 make up a comparator type differential amplifier. Q2 and Q3 drive Q6 and Q7 which in turn drive the +6 volt pass transistor, Q10. R24 allows the base of Q3 to be adjusted slightly negative with respect to ground. Q1 has a zener voltage of approximately 6.3 volts setting the base of Q2 slightly negative. R24 is adjusted to give an output of +6.00 volts. If the +6.00 volts tries to increase due to a change in line voltage or load current, the collector of Q1 becomes more positive. The base of Q2 becomes less negative (moves in a positive direction with respect to ground) and Q2 draws more current. The collector of Q2 moves less positive and this change is coupled through Q6 and Q7 to the base of Q10. This increases the resistance of Q10, returning the supply to +6.00 volts.

Q4 and Q5 form a comparator type differential amplifier in the -6.00 volt regulator. The base of Q4 is returned to ground through R6. The divider of R26 and R27 between the plus and minus 6 volt supplies sets the base of Q5 at ground. R9 allows a small adjustment of the currents in Q4 and Q5 to set the output and -6.00 volts. An increase in the -6 volts due to line voltage variation or load current variation, results in the base of Q5 moving negative. The collector of Q5 moves less negative (in a positive direction). This change is coupled to the bases of Q11 and Q12. Q11 and Q12 form a Darlington connected pass transistor pair for added gain. The positive going change, increases the resistance of Q11 and Q12, returning the output to -6.00 volts.

OUTPUT AMPLIFIER

Q13 through Q18 form an operational output amplifier with a gain of approximately -6 set by feedback resistor R37 and the input resistor made up of R31 and R32. Transistors Q13 and Q14 are a differential input stage driving a second differential stage of Q15 and Q16. The output is taken off single ended at the collector of Q16 and coupled to the push-pull emitter follower, Q17 and Q18. Diodes CR5 and CR6 provide bias for the push-pull emitter follower to prevent crossover distortion. The output is coupled through R50 and R51 to pin 3. C10 and C11 allow the amplifier to be high frequency compensated and are adjusted to give the best Gaussian response when a 1MHz square wave is applied. Ac is coupled from the transformer to pins 1 and 2 and drives the bridge rectifier made up of diodes CR7 through CR10. The outputs of the bridge rectifier are filtered by C14 and C15 providing the supply voltages for the output amplifier. R41 is the dc balance control allowing the output to be adjusted for symmetry about ground. R41 is a screwdriver adjustment available from the rear panel. DC OFFSET MODIFICATION: To convert the dc Balance control, R41, to a dc Offset control, remove R40 and R42, 10K 1% and replace with 2K 5% carbon resistors. R41 will now serve as a dc offset control allowing the power amplifier output to be offset approximately ±5vdc. It should be remembered that using an offset control limits the available peak output signal. The output will deliver 100ma into a short circuit and 32.5 volts peak to peak into an open circuit. When terminated in 600Ω, the amplifier will deliver 30 volts peak to peak. When terminated in 50Ω, the amplifier will deliver 10 volts peak to peak. When offset +5vdc, the output when terminated in 600Ω is only capable of swinging +10 volts peak. When offset +5vdc and terminated in 50Ω, the output is at its positive going limit point.

BATTERY REGULATOR BOARD

The battery regulator delivers + and - 6 volts dc to the Models 110B and 111B from a pack of 1.2 ampere-hour rechargeable Nickel Cadmium batteries. The +6 and -6 volt regulators are equivalent circuits and operate in the same manner as the ac regulators on the standard supply board. Q13 is the series pass transistor for the + supply and Q21 is the series pass transistor for the - supply. Q17 and Q25 act as zener references for the two supplies. R19, Q9 and CR9 make up the "starting" circuit. This assures that the supplies achieve full output when first turned on. R27, Q14 and R42, Q22 provide "current limiting" circuit which engages when the voltage across R27 (or R42 for - supply) reaches approximately .6 volts. Q14 (Q22 for - supply) conducts and limits the current through the series pass transistor. This occurs at approximately 340ma.

Transistors Q1 through Q7 make up the charging circuit. The batteries are always being charged as long as SW1 is on and the line cord is plugged in an ac source. The transformer delivers center-tapped ac to pins 1 and 2. The ac is rectified by diodes CR1, CR2, CR3 and CR4 and filtered by C1 and C2,

providing +24 and -24 volts dc. R10, R11, R14 and R15 sample the charging current through the batteries and provide forward bias to Q6 and Q7 through divider R8, R9, R13 and potentiometer R12. When potentiometer R12 is turned maximum counter-clockwise, the current through the current sampling resistors should be approximately 40ma to bias Q6 and Q7 on. When this occurs the current through Q1, Q2, Q3 and Q4 is reduced and an equilibrium charge rate is reached. Turning R12 fully clockwise adjusts the bias on Q6 and Q7 such that approximately 120ma of charge current is required for equilibrium. **Charge rate is adjustable from the rear panel.**

This method sampling the battery current provides an essentially constant charge rate regardless of load current. It also yields an overall negative temperature coefficient which is necessary for extended battery life.

When SW1 is in the OFF position, and the power cord is connected to an ac source, R6 and R18 provide a "trickle" charge of approximately 5ma. This **maintains the batteries at full charge during idle periods.**

Since there is no 30 volt output amplifier in the battery instruments, the attenuator wiper arm is connected to the output binding post through a 470Ω resistor. This provides a maximum output of 5 volts peak to peak at 600Ω **output impedance (2.5 volts ramp).**

MODEL 110, FRONT PANEL

The Model 110 front panel board has the frequency ranging capacitors and resistors with their associated switch, the frequency dial potentiometer, the output amplifier function selector switch and attenuator potentiometer, the five fixed output connectors, and the power amplifier output connectors.

The output of the power amplifier is available on pin 19 and is coupled through R28 to the front panel. C13 attenuates those frequencies beyond the band pass of the power amplifier to insure clean waveforms. R30 is normally jumpered. The parallel resistance of R28 and R29 in series with the parallel resistance of two 49.9Ω resistors on the power supply and output amplifier board make up the parallel resistance of the power amplifier. The jumper around R30 is removed when a 600Ω output resistance is desired. The fixed amplitude triangle, sine, sync and the two square wave outputs are fed to BNC connectors. Resistors R17, R18 and R21 set the output resistance of the sine, triangle and 5 volt square wave outputs. R25 and R23 attenuate and establish the output resistance of the 10nsec. square wave output. C8, C9, C11, C12 and R24 are high frequency roll-off components to insure clean waveforms. The 10 volt peak to peak square wave is also fed to the top of the frequency dial potentiometer. The frequency dial potentiometer attenuates the square wave and drives the selected integrating resistor. R16 insures that a square wave is delivered to the integrator when the frequency dial is turned fully clockwise. R20 provides an initial offset current to start

the Model 110 when the unit is first turned ON.

Wafers 1 and 2 of the frequency hertz switch select the appropriate integrating capacitors and resistors for the different frequency ranges. Wafer 3 selects resistors to ground from the center arm of the frequency dial potentiometer so that the dial potentiometer has the same resistive loading when different integrating resistors are selected. Wafer 4 selects resistors for the plus input of the integrator when different integrating resistors are used so that the source current in the + and - inputs of the integrator flow in the same resistances and do not develop an offset voltage.

MODEL 111, FRONT PANEL

The Model 111 front panel is similar to the Model 110 front panel with the addition of the VCG input connectors, the frequency vernier control, the X.3-X1 switch and the ramp output connector. In addition, the dial rather than attenuating the square wave and driving the integrator, attenuates the +6 volt supply voltage and provides an input to the first VCG amplifier. The frequency vernier is returned through R30 to -6 volts. The center arm of the vernier potentiometer provides a second input to the first VCG amplifier. In the "cal" position, the vernier potentiometer is fully clockwise and there is no vernier input to the VCG. In the counter-clockwise position of the vernier, a negative voltage is applied to the VCG and the frequency is reduced by approximately one minor dial division. The frequency hertz switch selects the appropriate integrating capacitors and resistors like the Model 110; however, the added X.3-X1 switch allows an added resistor to be placed in series with the selected integrating resistor when this switch is in the X.3 position. The added resistor is of such a value as to reduce the frequency to .3 of its X1 value.

MODEL 111, VCG BOARD

Refer to the VCG schematic. The two VCG amplifiers are similar operational inverting amplifier configurations. The basic operational amplifier is a μA702C integrated circuit. IC1 is the first inverting operational VCG amplifier, and serves as the main frequency control. The dial voltage from the front panel is available on pin 9 and applied through R6 to the summing node of the operational amplifier.

The voltage from the vernier potentiometer on the front panel is available on pin 8 and applied through R5 to the summing node of the operational amplifier. Any voltage applied to the front panel VCG input connector is applied to pin 4 through the potentiometer, R8, and the resistor, R7, to the summing node of the operational amplifier. The resultant output is the sum of the input voltages.

In the case of the more complex Models 115 and 116, a phase lock voltage is present on pin 6, and coupled through the filter network made up of R1, R2,

R3, C1 and C2 to the summing node of the operational amplifier. The components are not added in a Model 111.

R4 is not included on the VCG board in the other models. R4 allows a calibration of the effect of a VCG voltage applied on the front panel to the output frequency of the instrument. CR1 and CR2 provide protection in case of an over voltage applied at the VCG input terminal.

R9, R10 and R11 provide a zero adjust network for the non-inverting input to the operational amplifier. R51, R52 and R53 provide source current for the input of the first amplifier allowing summing node zero adjustment. R12 and R15 are the feedback resistors in the first operational amplifier. R13 is adjusted for frequency calibration at the low end of the dial.

Pin 7 is the output point of the operational amplifier and Q1 serves an emitter follower to provide added current swing in the negative direction at the output of the first VCG amplifier. The output at the emitter of Q1 is coupled through saturated transistor Q3 to the feedback resistor R13 and also to the input resistors of the second VCG amplifier made up of R14 and R15.

The square wave output from the output switch on the Main Board is available on pin 13, and applied through R17 to the base of Q2. When the square wave is negative Q2 is turned on and saturated and the output of the first VCG amplifier is coupled through Q2 to pin 7, the VCG out terminal.

When the square wave is positive, Q2 is turned off. Q2 and Q3 serve as inverted switches. Q2, operating as an inverted switch, has a very low saturation voltage; however, to compensate for this voltage, Q3 is placed in the feedback loop of the first operational amplifier. This also temperature compensates the first VCG amplifier.

The first operational amplifier has a gain of approximately 5/5 with respect to the dial input, while the second operational amplifier has a gain of unity. The output of the first VCG amplifier is coupled through R14 and R15 to the summing node of the first operational amplifier.

R25 serves as a feedback resistor in the second operational amplifier. Q4 and Q5 serve the same purpose in the second operational amplifier as Q2 and Q3 in the first. However, the output of the second operational amplifier is moving positive, therefore, NPN transistors are used.

When the square wave from pin 13 is positive, Q4 is turned on and saturated coupling the output of the second VCG amplifier to pin 7 the VCG out terminal. Therefore, the signal on pin 7 is a square wave whose frequency is determined by the switching rate of the output switch set on the Main Board and whose amplitude is dependent on the levels at the output of the two VCG amplifiers.

Since the second VCG amplifier has a unity gain, it will provide an output of opposite polarity but of the same magnitude as the output of the first VCG amplifier. The square wave on pin 7 is that square wave applied to the input of the integrator on the Main Board and in turn determines the frequency of the generator.

R46 and R24 serve as the zero adjust control for the second VCG amplifier. R14 allows adjustment of the symmetry at the high end of the dial, while R46 allows adjustment of the output frequency symmetry at the low end of the dial.

IC1 and IC2, the two integrated circuits, require a +12 volt supply at pin 8. The positive high voltage supply from the power amplifier on the power supply and power amplifier board is coupled to pin 5 of the VCG board, on to the collector of Q6 and in turn, to pin 8 of both the integrated circuits.

Q6 is a transistor connected and operated as a 6 volt zener diode. The emitter of Q6 is returned to +6 volts; therefore, its collector will be 6 volts above this level or +12 volts with respect to ground. Q6 thus serves as the +12 volt regulating element for the supply for the integrated circuits. When properly calibrated the system is so well balanced that it cannot start when the machine is first turned on. The square wave output from the VCG clamp transistors on pin 7 drives the input to the integrator.

R22 is added to provide an initial unbalance to allow the integrator to start. Once the machine is running, resistors R18 and R28 offset this unbalance introduced by R22 and the system is once again balanced.

MODEL 111, RAMP CIRCUIT

The triangle wave is available on pin 1 and is offset and attenuated by resistors R31, R32, R33, R34, and R35 so that its most positive excursion is 0 volts d-c and its most negative excursion is -2.5 volts. Transistors Q7 and Q8 are turned on and saturated by the negative going portion of the square wave applied to their bases through R37 and R38. When turned on, Q7 and Q8 chop the positive going portion of the offset triangle to ground. The result is the negative going 2.5 volt ramp in phase with the negative going portion of the triangle output. The ramp is delivered to pin 12 through the two emitter followers Q15 and Q16. The two opposing base to emitter voltages insure that the ramp starts at ground and that the emitter followers temperature compensate each other.

SECTION IV
CALIBRATION

MODEL 110; CALIBRATION PROCEDURE

EQUIPMENT REQUIRED

1. Voltmeter, 1% accuracy, 1 mv resolution (WAVETEK Model 201 or equivalent).

*2. Oscilloscope, Tektronix 530 series or equivalent.

*3. Plug-in, Tektronix type W or equivalent.

4. Plug-in, Tektronix type CA or equivalent.

5. Frequency counter, 5 digit resolution.

6. Distortion analyzer, Hewlett Packard Model 330C or equivalent.

7. Two only 50Ω cables with BNC connectors, 50Ω termination.

*If Tektronix scope and type W are not available, any peak reading device with an accuracy of 1% or better can be used.

Remove cover from instrument.

POWER SUPPLY BOARD (REAR ETCHED CIRCUIT BOARD)

Two 100 μf bypass capacitors are located in the bottom of the instrument; these are filter capacitors for the +6 volts and -6 volts power supplies. The capacitor toward the rear of the instrument is in the +6 volt supply and the other is in the -6 volt supply. The capacitor leads are convenient voltage test points. Connect an appropriate measuring device between the end marked plus (+) of the rear 100 μf capacitor and circuit ground. Adjust R24 for +6.00 volts ±1 mv. Move the measuring device to the other capacitor between the end marked minus (-) and circuit ground. Adjust R9 for -6.00 volts ±1 mv. To compensate for the effects of interaction, repeat these adjustments.

There is no adjustment in the +24 and -24 volt supplies.

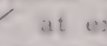
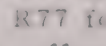
Typical 120 cycle ripple in the ±6 volt supplies is less than 25 mv.

Typical 120 cycle ripple in the ±24 volt supplies is less than 500 mv.

MAIN BOARD (SECOND ETCHED CIRCUIT BOARD FROM FRONT PANEL)

1. Set range at X10KHz at top of frequency dial. Monitor the fixed triangle output and adjust R4 for minimum ringing on triangle. Set range to X100KHz and readjust R4 for linearity of the triangle at 1MHz. It may be necessary to repeat adjustments of R4 several times to insure optimum triangle linearity at 1MHz and minimum ringing at 100KHz.

2. Rotate the dial to the extreme clockwise position. Connect a lead between the center arm of the dial potentiometer and circuit ground. Install a 100K resistor between pin 1 and pin 3 of the main board. Observe integrator output with the appropriate indicating device at the junction of R17 and R18. Adjust R8 for zero volts at X100, extreme bottom of the dial. Remove jumper wire and 100K resistor.

3. Using Tektronix scope and type W plug-in, observe triangle at front panel connector, open circuit. Adjust R78 in the switch set for the triangle break  at exactly -2.50 volts. Use comparison voltage on the type W plug-in and adjust R77 for the triangle break  at exactly +2.50 volts. To compensate for effects of interaction, repeat the adjustments.

4. Observe the 15nsec. square wave for leading edge spikes with a 50Ω cable terminated into 50Ω. Adjust R104 for plus and minus 2.5 volts ±1mv. Adjust R79 for symmetry about ground. Tolerance on spikes is 5% of the total peak to peak amplitude. Set the range switch X100, rotate the dial, measuring the frequency at the 10nsec. BNC connector with a 50Ω cable and 50Ω termination and counter. Set the dial reading to 10 (1000Hz) and tighten the setscrew. Set the dial at 1 and adjust R8 for time symmetry.

5. Observe the 10nsec. square wave output on an oscilloscope to be free of excessive leading edge spikes, X100K top of the frequency dial, using a 50Ω cable terminated in 50Ω.

POWER AMPLIFIER (REAR ETCHED CIRCUIT BOARD)

Set output amplifier function selector front panel switch on square wave. Set attenuator fully clockwise. Observe front panel output GR connector on oscilloscope open circuited and adjust R31 for a 32.5 volt peak to peak square wave.

Adjust square wave with output attenuator fully counter-clockwise for symmetry about ground with R41. Adjust 1MHz square wave into open circuit with C11 for an optimum square wave with no overshoot. Check for less than 100nsec. rise time. Check for 30 volts into 600Ω, and 10 volts into 50Ω.

SINE WAVEFORM ADJUSTMENTS (SECOND ETCHED BOARD FROM THE FRONT PANEL)

Place the main board on extended cable. Observe the sine wave at the BNC connector, open circuited. Using a Tektronix scope and type W plug-in, set the frequency dial at 10, range X100.

Adjust R64 for sine out of ±2.5 volts. Adjust R60 for sine symmetry about ground. Using distortion analyzer, adjust R20, R24, R30, R33, R38, R41, R46 and R49 for minimum harmonic distortion. Readjust R64 and R60 for amplitude and symmetry about ground.

CHECK RANGES (FRONT PANEL BOARD, FIRST ETCHED CIRCUIT BOARD)

Check all fixed ranges for frequency tracking. Trim resistors have been installed on individual ranges for tracking. Adjust C3 for proper tracking on X10K range. A trim resistor has been installed between position 3 and position 5 on wafer 1 of the range switch for proper tracking on X1K range. Adjust C1 for proper tracking on X100K range.

MODEL 111; CALIBRATION PROCEDURE

EQUIPMENT REQUIRED

1. Voltmeter, 1% accuracy, 1mv resolution (WAVETEK Model 201 or equivalent).

*2. Oscilloscope, Tektronix 530 series or equivalent.

*3. Plug-in, Tektronix type W or equivalent.

4. Plug-in, Tektronix type CA or equivalent.

5. Frequency counter, 5 digit resolution.

6. Distortion analyzer Hewlett/Packard Model 330C or equivalent.

7. Two 50Ω cables with BNC connectors, 50Ω termination.

*If Tektronix scope and type W plug-in are not available, any peak reading device with an accuracy of 1% or better can be used.

Remove cover from the instrument.

POWER SUPPLY BOARD (REAR ETCHED CIRCUIT BOARD)

Two 100μf bypass capacitors are located in the bottom of the instrument

which are filter capacitors for the +6 volts and -6 volts power supplies. The capacitor toward the rear of the instrument is in the +6 volt supply, and the other is in the -6 volt supply. The capacitor leads are convement voltage test points. Connect an appropriate measuring device between the end marked plus (+) of the rear 100μf capacitor and circuit ground. Adjust R24 for +6.00 volts ±1mv. Move the measuring device to the other capacitor between the end marked minus (-) and circuit ground. Adjust R9 for -6.00 volts ±1mv. To compensate for the effects of interaction, repeat these adjustments.

There is no adjustment in the +24 and -24 volt supplies.

Typical 120 cycle ripple, ±6 volt supplies is 250μv.

Typical 120 cycle ripple, ±24 volt supplies is 250mv.

MAIN BOARD (SECOND ETCHED CIRCUIT BOARD FROM FRONT PANEL)

1. Set range at X10KHz at top of frequency dial. Monitor the fixed triangle output and adjust R4 for minimum ringing on triangle. Set range to X100KHz and readjust R4 for linearity of the triangle at 1MHz. It may be necessary to repeat adjustments of R4 several times to insure optimum triangle **linearity at 1MHz and minimum ringing at 100KHz.**

2. Set the generator at X100, the extreme bottom of the frequency dial. Use a jumper to short pin 7, VCG board to circuit ground. Install a 100K resistor between pin 1 and pin 3 of the main board. Observe the integrator output with an appropriate indicating device at the junction of R17 and R18. Adjust R8 for zero volts. Remove the jumper wire and the 100K resistor.

3. Using Tektronix scope and a type W plug-in, observe the triangle at the front panel connector, open circuit. Adjust R78 in the switch set for the triangle break ⟍⟋ at exactly -2.50 volts (use comparison voltage on the type W plug-in). Adjust R77 for the triangle break ⟋⟍ at exactly +2.50 volts. To compensate for the effects of interaction, repeat the adjustments.

4. Observe the 15nsec. square wave for leading edge spikes with a 50Ω cable terminated into 50Ω. Adjust R104 for + and -2.5 volts ±1mv. Adjust R99 for symmetry about ground. Tolerance on spikes is 5% of the total peak to peak amplitude.

5. Observe the 10nsec. square wave output on an oscilloscope to be free of excessive leading edge spikes (X100K top of the frequency dial, using 50Ω cable terminated into 50Ω).

POWER AMPLIFIER (REAR ETCHED CIRCUIT BOARD)

Set output amplifier function selector (front panel) switch on square wave. Set the attenuator fully clockwise. Observe the front panel output GR connector on an oscilloscope open circuited and adjust R31 for a 32.5 volt peak to peak square wave.

Adjust the square wave with the output attenuator fully counter-clockwise for symmetry about ground with R41. Adjust 1MHz square wave into an open circuit with C11 for optimum square wave with no overshoot. Check for less than 100nsec. rise time. Check for 30 volts into 600Ω, and 10 volts into 50Ω.

SINE WAVEFORM ADJUSTMENTS (SECOND ETCHED BOARD FROM FRONT PANEL)

1. Using a Tektronix scope and type W plug-in, set the frequency dial at 10, range at X100. Place the main board on extender cable. Observe the sine wave at the BNC connector.

2. Adjust R64 for sine wave out of ±2.5 volt ±1mv. Adjust R60 for sine symmetry about ground. Using a distortion analyzer, adjust R20, R24, R30, R33, R38, R41, R46 and R49 for minimum harmonic distortion. Readjust R64 and R60 for amplitude and symmetry about ground.

VCG BOARD FREQUENCY (THIRD ETCHED BOARD FROM FRONT PANEL)

(For instruments having first amplifier summing node zero adjustment.)

Measure ±6 volt power supplies (refer to Power Supply Board Calibration Procedure, page 4-11).

1. With Frequency Hertz switch at X100, Frequency Vernier full CW, set Frequency Dial to 10, measure voltage at potentiometer wiper arm (pin 9 on the VCG Board) to be +5.750 volts ±2mv. If this condition is not met, reinstall the dial.

2. Dial tracking adjustment:

With Frequency Hertz switch X100, Vernier full CW, set dial to 10 and adjust R13 for 1000Hz and R14 for time symmetry. Set the dial to 1. By alternately shorting and opening the VCG input terminals, adjust R9 for a minimum frequency shift.

NOTE

Frequency shift is caused by non-zero summing node at the first VCG amplifier. R9

is used to adjust this for zero volts and no frequency shift.

Adjust R31 (source current potentiometer) and R46 for 100Hz and time symmetry. Repeat steps for adjustment of R13 and R14 and adjustment of R9 until frequency, symmetry and source current are all calibrated at the top (1000Hz) of the dial and the bottom (100Hz) of the dial.

3. VCG input calibration:

With Frequency Hertz switch X100, Frequency Vernier Potentiometer full CW, adjust dial for 100Hz on frequency measuring device. Apply +4.500 volts on the VCG input on the front panel and adjust R8 for 1000Hz.

RAMP ADJUSTMENT

Observe the ramp output at the BNC connector with 50Ω cable terminated into 50Ω load. Adjust R34 so that the signal is neither nor but is .

Adjust R33 for -2.5 volts peak ramp output into an open circuit.

CHECK RANGES (FRONT PANEL BOARD, FIRST ETCHED CIRCUIT BOARD)

Check all fixed ranges for frequency tracking. Trim resistors have been installed on individual ranges for tracking. Adjust C5 for proper tracking on X10K range. A trim resistor has been installed between position 3 and position 5 on wafer 1 of the range switch for proper tracking on the X1K range. Adjust C1 for proper tracking on X100K range.

SECTION V
PARTS LIST

GENERAL

This section contains a list of replaceable electronic parts and assemblies in the equipment; structural items and hardware such as screws and nuts are not included.

PARTS LIST ARRANGEMENT

The parts list starts with the Chassis Assembly, followed by a list of components found on the chassis as well as the major modular components.

LIST OF MANUFACTURERS

The MANUFACTURER (MFR) column of the parts list uses brief descriptions; the names are given in full below.

A. H. H.	Arrow, Hart and Hegeman, Hartford, Connecticut
Allen Bradley	Allen Bradley, Milwaukee, Wisconsin
Amphenol	Amphenol Corporation, Chicago, Illinois
Arco	Arco Electronics, Great Neck, L. I., New York
CDE	Cornell Dubilier, Division of Federal Pacific Electric Company, Newark, New Jersey
Continental	Continental-Wirt Electronics Corporation, Philadelphia, Pennsylvania
Corning	Corning Glass Works, Bradford, Pennsylvania
CRL	Centralab, Division of Globe-Union, Milwaukee, Wisconsin
CTS	Chicago Telephone Systems, Los Angeles, California
Elpac	Elpac Incorporated, Fullerton, California
Erie	Erie Technological Products Incorporated, Erie, Pennsylvania
Eveready	Eveready Batteries, Union Carbide Corporation, Los Angeles, California

Fairchild	Fairchild Semiconductor Corporation, Palo Alto, California
G. E.	General Electric Company, Semiconductor Products Division, Buffalo, New York
Grayhill	Grayhill Incorporated, La Grange, Illinois
IRC	International Resistance Company, Philadelphia, Pennsylvania
Johnson	E. F. Johnson Company, Waseca, Minnesota
Kings	Kings Electronics Company Incorporated, Tuckahoe, New York
Littelfuse	Littelfuse Incorporated, Des Plaines, Illinois
Motorola	Motorola Semiconductor Products, Phoenix, Arizona
RCA	RCA Semiconductor Division, Somerville, New Jersey
Richey	Richey Electronics, Nashville, Tennessee
Semtech	Semtech Corporation, Newbury Park, California
Smith	H. H. Smith Incorporated, Brooklyn, New York
SEC	Southern Electronics Corporation, Burbank, California
Sprague	Sprague Electric Company, North Adams, Massachusetts
Stackpole	Stackpole Carbon Company, St. Mary's, Pennsylvania
Wakefield	Wakefield Engineering Incorporated, Wakefield, Massachusetts

MATCHED OR PAIRED PARTS

Prior to ordering or replacing electronic components in the equipment, refer to the notes regarding matched or paired parts on the schematic diagrams in Section VI.

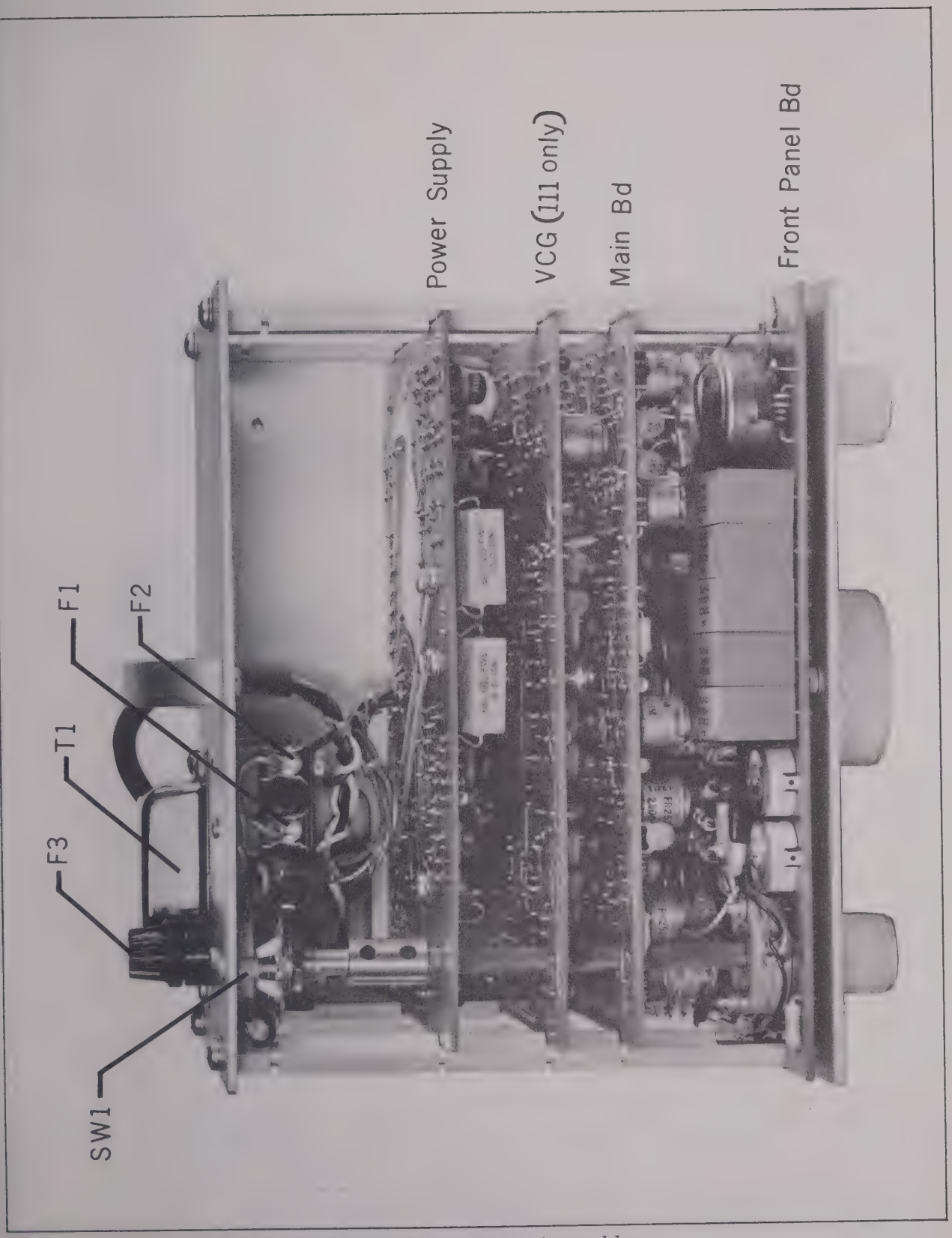


Figure 5-1. Chassis Assembly.

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
F1, F2	313.250	*FUSE, $\frac{1}{4}$ amp, Slo-Blo	2	Littelfuse
F3	312.750	FUSE, 3/4 amp, Slo-Blo	1	Littelfuse
SW1	110-SW2	SWITCH ASSY	1	Wavetek
T1	110-500	TRANSFORMER	1	Wavetek
	110-011	FRONT PANEL ASSY (Model 110)	1	Wavetek
	111-017	FRONT PANEL ASSY (Model 111)	1	Wavetek
	110-012	MAIN BOARD ASSY	1	Wavetek
	111-018	VCG BOARD ASSY	1	Wavetek
	110-013	POWER SUPPLY and OUTPUT AMPLIFIER ASSY	1	Wavetek
	112-022	BATTERY REGULATOR BOARD ASSY	1	Wavetek
	110-010	MOTHER BOARD ASSY (Model 110)	1	Wavetek
	111-010	MOTHER BOARD ASSY (Model 111)	1	Wavetek
	110-039	MOTHER BOARD ASSY (Battery Models)	1	Wavetek
	110-038	CONNECTOR MOUNTING BOARD ASSY (Model 110 Rackmount Only)	1	Wavetek
	111-037	CONNECTOR MOUNTING BOARD ASSY (Model 111 Rackmount Only)	1	Wavetek

*For "B" models, use 1 amp, 3AG, Fast Blow.

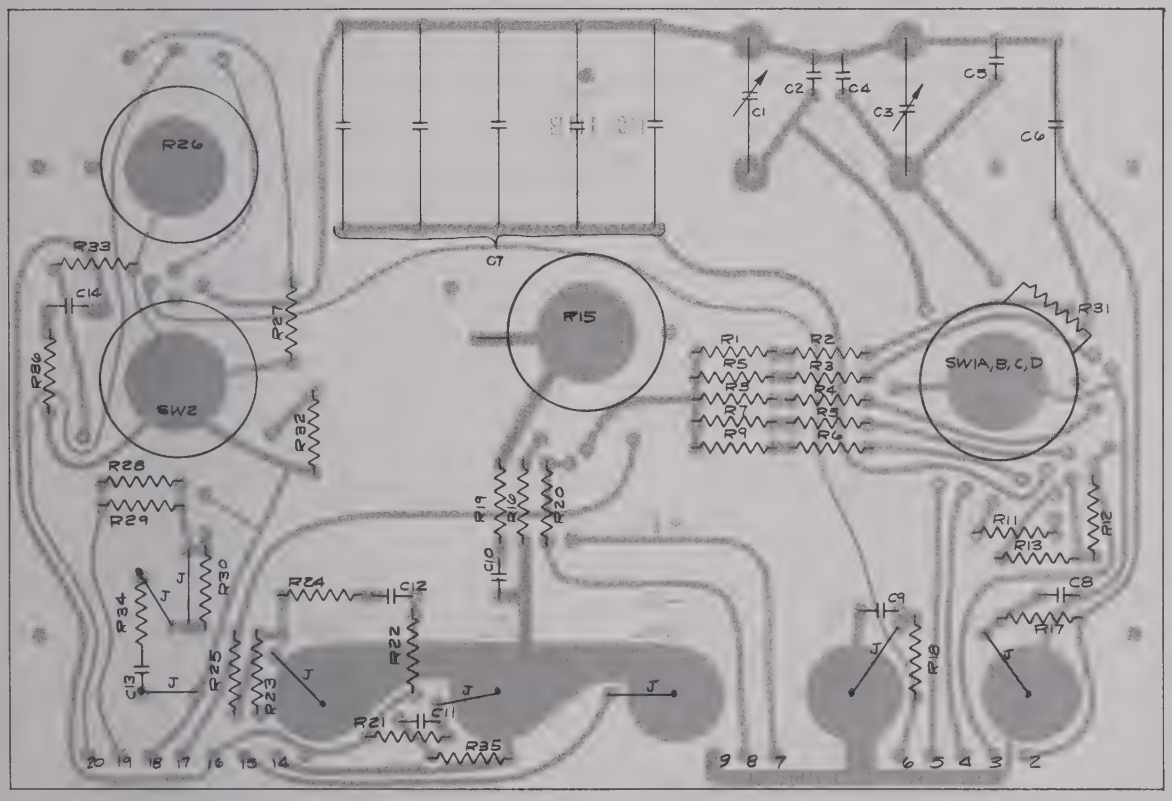


Figure 5-2
Front Panel Assembly (110-011)

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
R27, R35	RC20GF4R7J	RESISTOR, Carbon ½w, 5%, 4.7Ω	2	Stackpole
R34	RC20GF100J	RESISTOR, Carbon ½w, 5%, 10Ω	1	Stackpole
R19	RC20GF270K	RESISTOR, Carbon ½w, 10%, 27Ω	1	Stackpole
R24	RC20GF430J	RESISTOR, Carbon ½w, 5%, 43Ω	1	Stackpole
R23	RC20GF560K	RESISTOR, Carbon ½w, 10%, 56Ω	1	Stackpole
R36	RC20GF201J	RESISTOR, Carbon ½w, 5%, 200Ω	1	Stackpole
R11, R25	RC20GF471K	RESISTOR, Carbon ½w, 10%, 470Ω	2	Stackpole
R30	RC20GF561K	RESISTOR, Carbon ½w, 10%, 560Ω	1	Stackpole
R32, R33	RC20GF102J	RESISTOR, Carbon ½w, 5%, 1000Ω	2	Stackpole
R22	RC20GF103K	RESISTOR, Carbon ½w, 10%, 10,000Ω	1	Stackpole
R20	RC20GF123K	RESISTOR, Carbon ½w, 10%, 12,000Ω	1	Stackpole
R16	RN60D	RESISTOR, Metal Film ¼w, 1%, 21.5Ω	1	Corning
R17, R18, R21, R28, R29	RN60D	RESISTOR, Metal Film ¼w, 1%, 49.9Ω	5	Corning
R2, R6	RN60D	RESISTOR, Metal Film ¼w, 1%, 4,640Ω	2	Corning

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
R12	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 42,200Ω	1	Corning
R4, R8	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 46,400Ω	2	Corning
R13	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 422,000Ω	1	Corning
R10	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 464,000Ω	1	Corning
R15, R16	JAIN104P102UA	POTENTIOMETER 1000Ω	2	Allen Bradley
C14	DD220	CAPACITOR, Ceramic 1000v, 22pf	1	CRL
C11	DD470	CAPACITOR, Ceramic 1000v, 47pf	1	CRL
C4	DM15-680J	CAPACITOR, Silver Mica, 500v, 5%, 68pf	1	Arco
C2	DM15-820J	CAPACITOR, Silver Mica, 500v, 5%, 82pf	1	Arco
C12	DD100	CAPACITOR, Ceramic 1000v, 100pf	1	CRL
C13	DD221	CAPACITOR, Ceramic 1000v, 220pf	1	CRL
C10	DD331	CAPACITOR, Ceramic 1000v, 330pf	1	CRL
C8	DD681	CAPACITOR, Ceramic 1000v, 680pf	1	CRL
C3	DM15-911F	CAPACITOR, Silver Mica, 500v, 1%, 910pf	1	Arco

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
C3	DD102	CAPACITOR, Ceramic 1000v, 1000pf	1	CRL
C6	PO104G1	CAPACITOR, Polystyrene, 100v, 1%, 0.1μf	1	SEC
C1, C5	503-001-COPO-37R	CAPACITOR, Variohm, 4.5 to 25pf	2	Erie
C7	ZX-3022	CAPACITOR, Matched to 1%, 5 x 2μf	1	Elpac
SW1	110-SW1	SWITCH	1	Wavetek
SW2	110-SW2	SWITCH, with T107 Wafer	1	Wavetek
	110-111	CIRCUIT BOARD, 1/16 Epoxy, 2oz. Copper	1	Wavetek

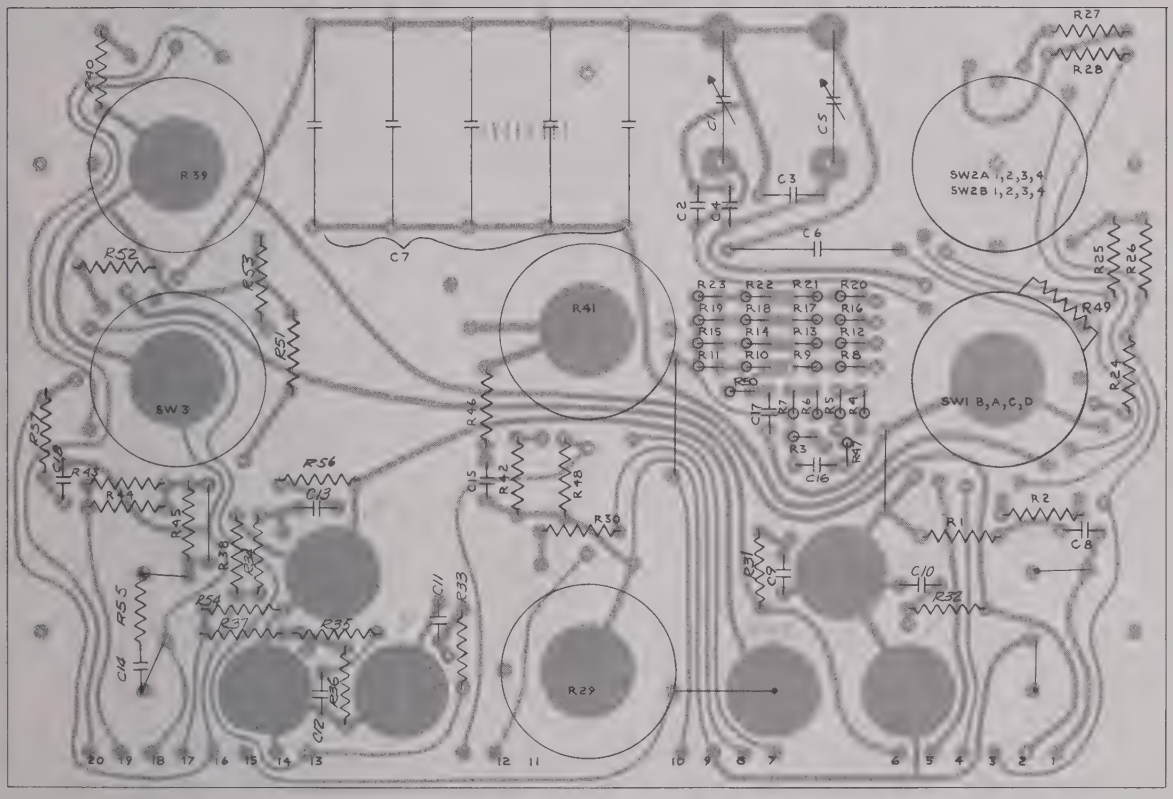


Figure 5-3
Front Panel Assembly (111-017)

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
R40, R56	RC20GF4R7J	RESISTOR, Carbon ½w, 5%, 4.7Ω	2	Stackpole
R55	RC20GF100J	RESISTOR, Carbon ½w, 5%, 10Ω	1	Stackpole
R46	RC20GF270K	RESISTOR, Carbon ½w, 10%, 27Ω	1	Stackpole
R35	RC20GF430J	RESISTOR, Carbon ½w, 5%, 43Ω	1	Stackpole
R57	RC20GF201J	RESISTOR, Carbon ½w, 5%, 200Ω	1	Stackpole
R2	RC20GF221K	RESISTOR, Carbon ½w, 10%, 220Ω	1	Stackpole
R1, R37	RC20GF471K	RESISTOR, Carbon ½w, 10%, 470Ω	2	Stackpole
R45	RC20GF561K	RESISTOR, Carbon ½w, 10%, 560Ω	1	Stackpole
R51, R52, R53	RC20GF102J	RESISTOR, Carbon ½w, 5%, 1000Ω	3	Stackpole
R54	RC20GF122K	RESISTOR, Carbon ½w, 10%, 1,200Ω	1	Stackpole
R24	RC20GF302J	RESISTOR, Carbon ½w, 5%, 3,000Ω	1	Stackpole
R38	RC20GF103K	RESISTOR, Carbon ½w, 10%, 10,000Ω	1	Stackpole
R30	RC20GF113J	RESISTOR, Carbon ½w, 5%, 11,000Ω	1	Stackpole
R42	RN60D	RESISTOR, Metal Film ¼w, 1%, 21.5Ω	1	Corning

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
R31, R32, R33, R34, R43, R44	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 49.9Ω	6	Corning
R15, R7	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 3,010Ω	2	Corning
R3	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 4,320Ω	1	Corning
R5, R13	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 6,980Ω	2	Corning
R48	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 8,250Ω	1	Corning
R11, R19, R26	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 30,100Ω	3	Corning
R9, R17, R25	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 69,800Ω	3	Corning
R23, R28	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 301,000Ω	2	Corning
R21, R27	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 698,000Ω	2	Corning
R29, R39, R41	JAIN104P102UA	POTENTIOMETER Single Turn, 1000Ω	3	Allen Bradley
C16	DD220	CAPACITOR, Ceramic 1000v, 22pf	1	CRL
C13	DD470	CAPACITOR, Ceramic 1000v, 47pf	1	CRL
C4	DM15-680J	CAPACITOR, Silver Mica, 15v, 5%, 68pf	1	Arco
C2	DM15-820J	CAPACITOR, Silver Mica, 15v, 5%, 82pf	1	Arco

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
C12	DD100	CAPACITOR, Ceramic 1000v, 100pf	1	CRL
C14	DD221	CAPACITOR, Ceramic 1000v, 220pf	1	CRL
C15	DD331	CAPACITOR, Ceramic 1000v, 330pf	1	CRL
C8	DD471	CAPACITOR, Ceramic 1000v, 470pf	1	CRL
C10, C11	DD681	CAPACITOR, Ceramic 1000v, 680pf	2	CRL
C9	DD102	CAPACITOR, Ceramic 1000v, 1000pf	1	CRL
C6	PO104G1	CAPACITOR, Polystyrene, 100v, 0.1μf	1	Arco
C7	ZX-3022	CAPACITOR, Mylar 5 x 2μf	1	Elpac
C1, C5	503-001-COPO-37R	CAPACITOR, Variohm 4.5 to 25pf	2	Erie
SW1	110-SW1	SWITCH	1	Wavetek
SW2A, SW2B		WAFER, From 104-SW3	2	Wavetek
SW3	110-SW2	SWITCH	1	Wavetek
	UG657/U	CONNECTOR, BNC	6	Kings
	111-103	BINDING POST	4	Johnson
	111-117	CIRCUIT BOARD, 1/16 Epoxy, 2oz. Copper	1	Wavetek

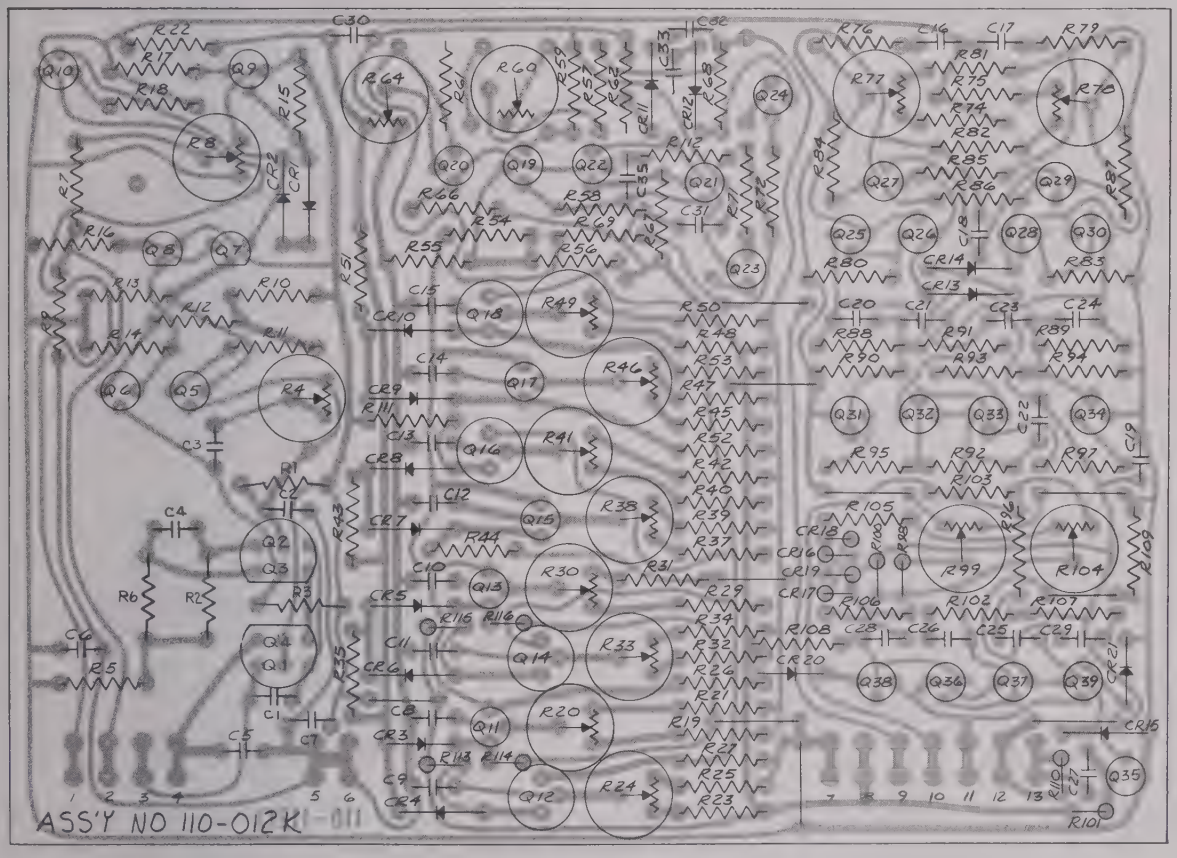


Figure 5-4

Main Board Assembly (110-012)

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
R17, R18, R71, R72	RC20GF4R7J	RESISTOR, Carbon ½w, 5%, 4.7Ω	4	Stackpole
R119	RC20GF300J	RESISTOR, Carbon ½w, 5%, 30Ω	1	Stackpole
R70, R73, R91, R93	RC20GF470K	RESISTOR, Carbon ½w, 10%, 47Ω	4	Stackpole
R92	RC20GF620J	RESISTOR, Carbon ½w, 5%, 62Ω	1	Stackpole
R102, R106, R107	RC20GF101K	RESISTOR, Carbon ½w, 10%, 100Ω	3	Stackpole
R16	RC20GF131J	RESISTOR, Carbon ½w, 5%, 130Ω	1	Stackpole
R55, R67	RC20GF151J	RESISTOR, Carbon ½w, 5%, 150Ω	2	Stackpole
R112	RC20GF271K	RESISTOR, Carbon ½w, 10%, 270Ω	1	Stackpole
R84, R87	RC20GF471K	RESISTOR, Carbon ½w, 10%, 470Ω	2	Stackpole
R90. R94	RC20GF561K	RESISTOR, Carbon ½w, 10%, 560Ω	2	Stackpole
R68, R88, R89, R101	RC20GF102K	RESISTOR, Carbon ½w, 10%, 1000Ω	4	Stackpole
R108, R109	RC20GF122K	RESISTOR, Carbon ½w, 10%, 1,200Ω	2	Stackpole
R96	RC20GF222K	RESISTOR, Carbon ½w, 10%, 2,200Ω	1	Stackpole

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
R85, R86	RC20GF472K	RESISTOR, Carbon $\frac{1}{2}$w, 10%, 4,700Ω	2	Stackpole
R110	RC20GF103K	RESISTOR, Carbon $\frac{1}{2}$w, 10%, 10,000Ω	1	Stackpole
R11, R12	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 100Ω	2	Corning
R103	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 316Ω	1	Corning
R26, R27, R105	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 511Ω	3	Corning
R35, R59, R61, R74, R75	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 825Ω	5	Corning
R2, R6, R15, R22, R54, R56	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 1000Ω	6	Corning
R113, R114	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 1,620Ω	2	Corning
R81, R82, R100	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 2,000Ω	3	Corning
R51	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 2,370Ω	1	Corning
R43	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 2,490Ω	1	Corning
R19, R25	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 2,870Ω	2	Corning
R9, R80, R83	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 3,010Ω	3	Corning
R29, R34	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 3,160Ω	2	Corning

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
R13, R14, R37, R42	RN60D	RESISTOR, Metal Film ¼w, 1%, 3,830Ω	4	Corning
R21, R23, R31, R32, R45, R47, R48, R50, R52, R53	RN60D	RESISTOR, Metal Film ¼w, 1%, 4,640Ω	10	Corning
R39, R40	RN60D	RESISTOR, Metal Film ¼w, 1%, 4,750Ω	2	Corning
R57, R69, R115, R116	RN60D	RESISTOR, Metal Film ¼w, 1%, 6,980Ω	4	Corning
R44, R58, R66, R111	RN60D	RESISTOR, Metal Film ¼w, 1%, 10,000Ω	4	Corning
R98	RN60D	RESISTOR, Metal Film ¼w, 1%, 21,500Ω	1	Corning
R5	RN60D	RESISTOR, Metal Film ¼w, 1%, 46,400Ω	1	Corning
R1, R3, R7	RN60D	RESISTOR, Metal Film ¼w, 1%, 110,000Ω	3	Corning
R20, R24, R30, R33, R38, R41, R46, R49, R60, R77, R78, R104	FR251M	POTENTIOMETER Single Turn, 250Ω	12	Allen Bradley
R4	FR501M	POTENTIOMETER Single Turn, 500Ω	1	Allen Bradley
R8, R64, R99	FR103M	POTENTIOMETER Single Turn, 10,000Ω	3	Allen Bradley
C26	DD050	CAPACITOR, Ceramic 1000v, 5pf	1	CRL
C22	DD100	CAPACITOR, Ceramic 1000v, 10pf	1	CRL

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
C20, C24, C25	DD220	CAPACITOR, Ceramic 1000v, 22pf	3	CRL
C30	DD330	CAPACITOR, Ceramic 1000v, 33pf	1	CRL
C21, C23, C35	DD470	CAPACITOR, Ceramic 1000v, 47pf	3	CRL
C1, C2	DD101	CAPACITOR, Ceramic 1000v, 100pf	2	CRL
C33	DD151	CAPACITOR, Ceramic 1000v, 150pf	1	CRL
C16*, C17*	DD221	CAPACITOR, Ceramic 1000v, 220pf	2	CRL
C3	DD391	CAPACITOR, Ceramic 1000v, 390pf	1	CRL
C27, C28, C29	DD471	CAPACITOR, Ceramic 1000v, 470pf	3	CRL
C4, C5, C8, C9, C10, C11, C12, C13, C14, C15	DD102	CAPACITOR, Ceramic 1000v, .001μf	10	CRL
C6, C7, C18, C19 C31, C32	UK10-104	CAPACITOR, Ceramic 10v, 0.1μf	6	CRL
CR1 thru CR21	FD6666	DIODE	21	Fairchild
Q1, Q2, Q3, Q4	TD101	TRANSISTOR, Dual	2	Sprague
Q12, Q14, Q16, Q18	2N3638	TRANSISTOR	4	Fairchild
Q5, Q6, Q10, Q21, Q22, Q24, Q25, Q28, Q29, Q31, Q33, Q37, Q38	2N5141	TRANSISTOR	13	Fairchild

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
Q11, Q13, Q15, Q17, Q19, Q20	2N3642	TRANSISTOR	6	Fairchild
Q7, Q8, Q9, Q23, Q26, Q27, Q30, Q32, Q34, Q35, Q36, Q39	2N5134	TRANSISTOR	12	Fairchild
	110-112	CIRCUIT BOARD, 1/16 Epoxy, 2oz. Copper	1	Wavetek

The following transistors are matched pairs:

Q5 & Q6, Q7 & Q8, Q19 & Q20,
Q21 & Q22.

*Model 110 Only.

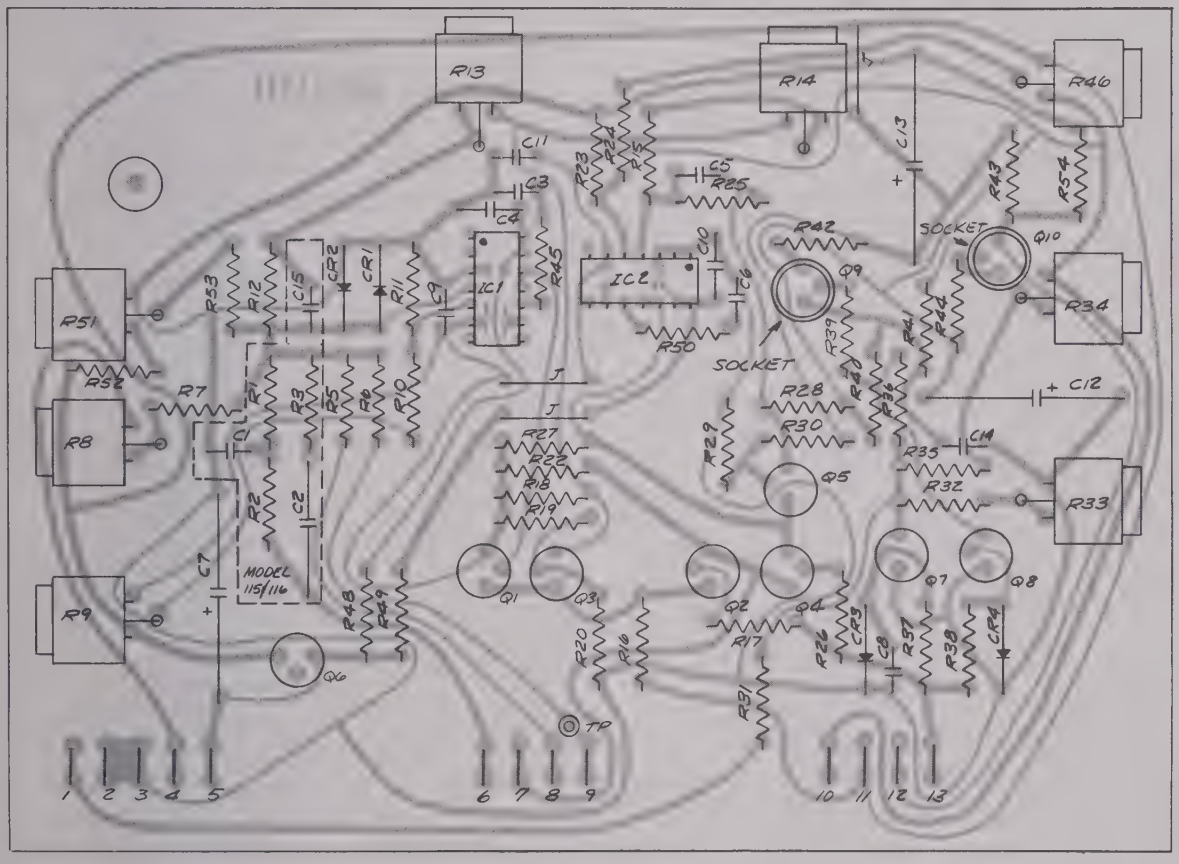


Figure 5-5
VCG Board Assembly (111-018)

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
R48, R49	RC20GF100K	RESISTOR, Carbon ½w, 10%, 10Ω	2	Stackpole
R42, R44	RC20GF470K	RESISTOR, Carbon ½w, 10%, 47Ω	2	Stackpole
R50	RC20GF910J	RESISTOR, Carbon ½w, 5%, 91Ω	1	Stackpole
R39, R41	RC20GF101K	RESISTOR, Carbon ½w, 10%, 100Ω	2	Stackpole
R45	RC20GF161J	RESISTOR, Carbon ½w, 5%, 160Ω	1	Stackpole
R54	RC20GF471K	RESISTOR, Carbon ½w, 10%, 470Ω	1	Stackpole
R40	RC20GF681K	RESISTOR, Carbon ½w, 10%, 680Ω	1	Stackpole
R43	RC20GF102K	RESISTOR, Carbon ½w, 10%, 1000Ω	1	Stackpole
R16	RC20GF122K	RESISTOR, Carbon ½w, 10%, 1,200Ω	1	Stackpole
R36	RC20GF182K	RESISTOR, Carbon ½w, 10%, 1,800Ω	1	Stackpole
R17, R26, R27	RC20GF202J	RESISTOR, Carbon ½w, 5%, 2,000Ω	3	Stackpole
R19, R30, R37, R38	RC20GF242J	RESISTOR, Carbon ½w, 5%, 2,400Ω	4	Stackpole
R20, R29	RC20GF123K	RESISTOR, Carbon ½w, 10%, 12,000Ω	2	Stackpole
R18, R22, R28	RC20GF224K	RESISTOR, Carbon ½w, 10%, 220,000Ω	3	Stackpole

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
R31	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 909Ω	1	Corning
R24	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 1,500Ω	1	Corning
R32	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 1,780Ω	1	Corning
R35	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 2,370Ω	1	Corning
R15	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 2,870Ω	1	Corning
R25	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 3,010Ω	1	Corning
R11	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 3,830Ω	1	Corning
R12	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 6,190Ω	1	Corning
R7	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 10,000Ω	1	Corning
R6	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 12,100Ω	1	Corning
R52	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 46,400Ω	1	Corning
R5	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 95,300Ω	1	Corning
R53	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 110,000Ω	1	Corning
R23, R10	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 464,000Ω	2	Corning

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
R13, R14, R33, R34	FR501M	POTENTIOMETER Single Turn, 500Ω	4	Allen Bradley
R8	FR102M	POTENTIOMETER Single Turn, 1000Ω	1	Allen Bradley
R9, R46, R51	FR103M	POTENTIOMETER Single Turn, 10,000Ω	3	Allen Bradley
C5	DD050	CAPACITOR, Ceramic 1000v, 5pf	1	CRL
C8	DD101	CAPACITOR, Ceramic 1000v, 100pf	1	CRL
C14	DD331	CAPACITOR, Ceramic 1000v, 330pf	1	CRL
C3, C6	CK102	CAPACITOR, Ceramic 50v, .001μf	2	CRL
C2	WMF1S33	CAPACITOR, Mylar 100v, 0.033μf	1	CDE
C9, C11	UK10-104	CAPACITOR, Ceramic 10v, 0.1μf	2	CRL
C4, C10	UK20-104	CAPACITOR, Ceramic 20v, 0.1μf	2	CRL
C7, C12, C13	16-375-100-15T	CAPACITOR, Electrolytic, 15v, 100μf	3	Richey
CR1, CR2, CR3, CR4	FD6666	DIODE	4	Fairchild
Q6*	2N3638	TRANSISTOR	1	Fairchild
Q4, Q5, Q9	2N5134	TRANSISTOR	3	Fairchild
Q1, Q2, Q3, Q7, Q8, Q10	2N5141	TRANSISTOR	6	Fairchild

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
IC1, IC2	MC1712CP	INTEGRATED CIRCUIT	2	Motorola
	111-118	CIRCUIT BOARD, 1/16 Epoxy, 2oz. Copper	1	Wavetek

*Delete on battery models.

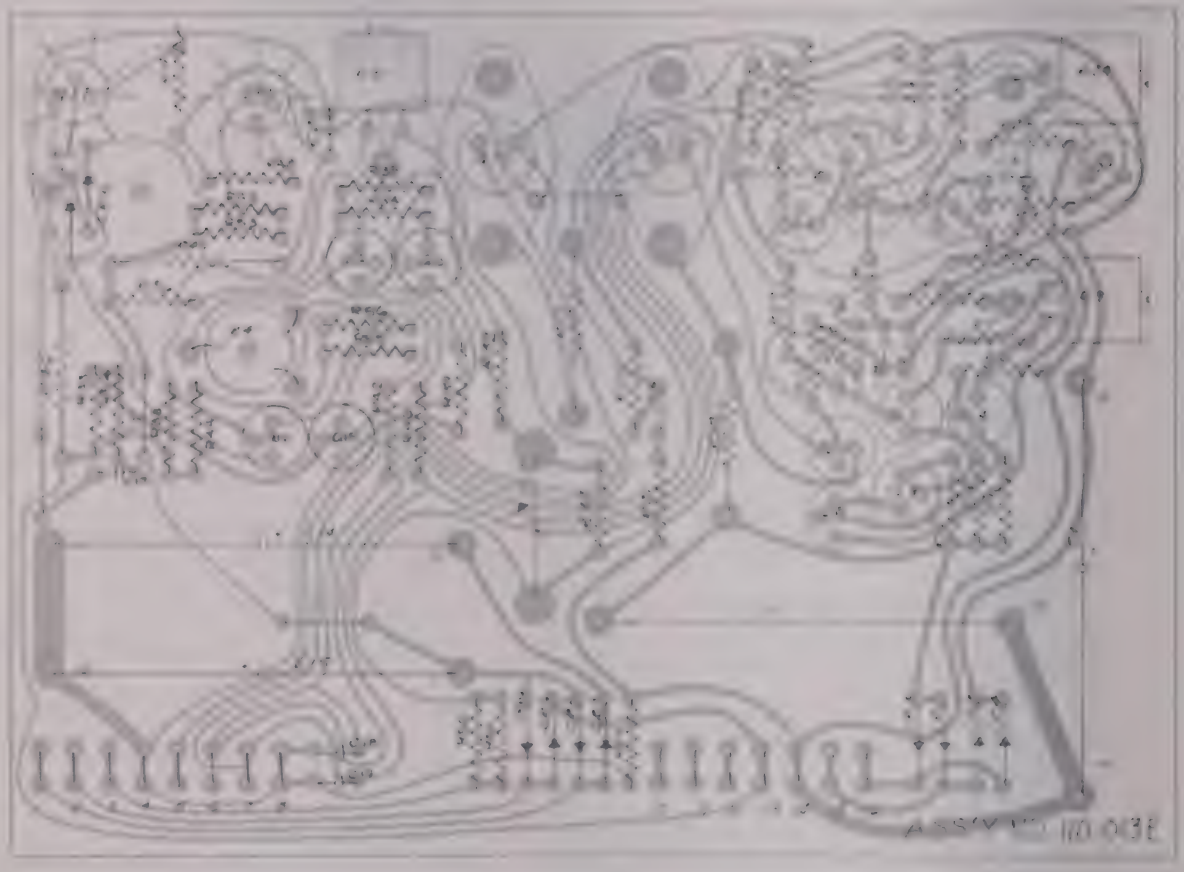


Figure 5-1

Power Supply and Output Amplifier Assembly (110.03E)

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
R47, R48	RC20GF6R8J	RESISTOR, Carbon $\frac{1}{2}$w, 5%, 6.8Ω	2	Stackpole
R21, R54, R55, R56	RC20GF100J	RESISTOR, Carbon $\frac{1}{2}$w, 5%, 10Ω	4	Stackpole
R57	RC20GF220J	RESISTOR, Carbon $\frac{1}{2}$w, 5%, 22Ω	1	Stackpole
R7	RC20GF560J	RESISTOR, Carbon $\frac{1}{2}$w, 5%, 56Ω	1	Stackpole
R46, R49	RC42GF910J	RESISTOR, Carbon 2w, 5%, 91Ω	2	Stackpole
R14, R17, R22, R23	RC20GF101J	RESISTOR, Carbon $\frac{1}{2}$w, 5%, 100Ω	4	Stackpole
R44	RC20GF221K	RESISTOR, Carbon $\frac{1}{2}$w, 10%, 220Ω	1	Stackpole
R5, R15, R16	RC20GF222K	RESISTOR, Carbon $\frac{1}{2}$w, 10%, 2200Ω	3	Stackpole
R3, R8, R12	RC20GF272K	RESISTOR, Carbon $\frac{1}{2}$w, 10%, 2700Ω	3	Stackpole
R45, R53	RC20GF362J	RESISTOR, Carbon $\frac{1}{2}$w, 5%, 3600Ω	2	Stackpole
R4, R11	RC20GF392K	RESISTOR, Carbon $\frac{1}{2}$w, 10%, 3900Ω	2	Stackpole
R20	RC20GF472K	RESISTOR, Carbon $\frac{1}{2}$w, 10%, 4700Ω	1	Stackpole
R36	RC20GF622J	RESISTOR, Carbon $\frac{1}{2}$w, 5%, 6200Ω	1	Stackpole
R50, R51	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 49.9Ω	2	Corning

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
R1, R28, R34, R35	RN60D	RESISTOR, Metal Film ¼w, 1%, 100Ω	4	Corning
R6	RN60D	RESISTOR, Metal Film ¼w, 1%, 511Ω	1	Corning
R12	RN60D	RESISTOR, Metal Film ¼w, 1%, 909Ω	1	Corning
R25, R26, R27, R31	RN60D	RESISTOR, Metal Film ¼w, 1%, 1000Ω	4	Corning
R2	RN60D	RESISTOR, Metal Film ¼w, 1%, 2,870Ω	1	Corning
R13, R38	RN60D	RESISTOR, Metal Film ¼w, 1%, 3,830Ω	2	Corning
R17	RN60D	RESISTOR, Metal Film ¼w, 1%, 6,980Ω	1	Corning
R40, R42	RN60D	RESISTOR, Metal Film ¼w, 1%, 10,000Ω	2	Corning
R18, R19	PW-10	RESISTOR, Wirewound 5w, 10%, 10Ω	2	IRC
R9, R24, R31	FR251M	POTENTIOMETER Single Turn, 250Ω	3	Allen Bradley
R41	FR103M	POTENTIOMETER Single Turn, 10,000Ω	1	Allen Bradley
C4	DD102	CAPACITOR, Ceramic 1000v, 1000pf	1	CRL
C12, C18	CK103	CAPACITOR, Ceramic 50v, .01μf	2	CRL
C3, C5, C6, C7, C8, C19, C20	UK10-104	CAPACITOR, Ceramic 10v, 0.1μf	7	Sprague

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
C14, C15	34-750-1000-35T	CAPACITOR, Electrolytic, 35v, 1000μf	2	Richey
C1, C2	34-750-2000-15T	CAPACITOR, Electrolytic, 15v, 2000μf	2	Richey
C11	503-001-COPO-17R	CAPACITOR, Variohm 3.0 to 12pf	1	Erie
CR5, CR6	FD6666	DIODE	2	Fairchild
CR1, CR2, CR3, CR4, CR7, CR8, CR9, CR10	SCE-1	DIODE	8	Semtech
Q17	2N3299	TRANSISTOR	1	Fairchild
Q15 & Q16, Q18	2N3502	TRANSISTOR	3	Fairchild
Q1, Q4 & Q5, Q7, Q9, Q11	2N3638	TRANSISTOR	6	Fairchild
Q13 & Q14	2N3642	TRANSISTOR	2	Fairchild
Q2 & Q3, Q6, Q8	2N5134	TRANSISTOR	4	Fairchild
Q12	2N3740	TRANSISTOR	1	Motorola
Q10	40250	TRANSISTOR	1	RCA
	NF207	HEATSINK	2	Wakefield
	110-113	CIRCUIT BOARD, 1/16 Epoxy, 2oz, Copper	1	Wavetek

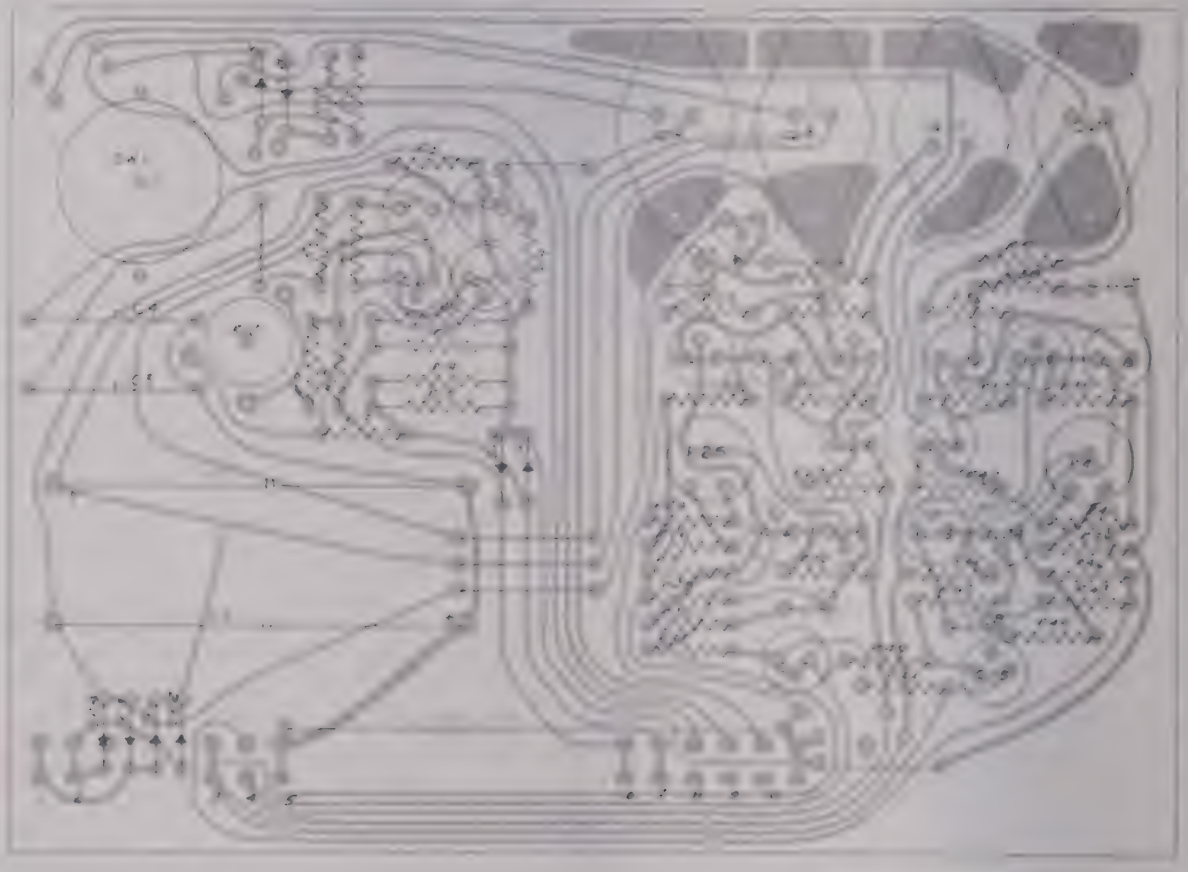


Figure 5-7
Battery Regulator Assembly (112-022)

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
R27, R42	RC20GF1R8J	RESISTOR, Carbon $\frac{1}{2}$w, 5%, 1.8Ω	2	Stackpole
R23, R30, R38, R45	RC20GF100K	RESISTOR, Carbon $\frac{1}{2}$w, 10%, 10Ω	4	Stackpole
R9	RC20GF430J	RESISTOR, Carbon $\frac{1}{2}$w, 5%, 43Ω	1	Stackpole
R8, R13	RC20GF620J	RESISTOR, Carbon $\frac{1}{2}$w, 5%, 62Ω	2	Stackpole
R21, R37	RC20GF201J	RESISTOR, Carbon $\frac{1}{2}$w, 5%, 200Ω	2	Stackpole
R20, R36	RC20GF911J	RESISTOR, Carbon $\frac{1}{2}$w, 5%, 910Ω	2	Stackpole
R22, R35	RC20GF162J	RESISTOR, Carbon $\frac{1}{2}$w, 5%, 1,600Ω	2	Stackpole
R6, R18	RC20GF202J	RESISTOR, Carbon $\frac{1}{2}$w, 5%, 2,000Ω	2	Stackpole
R29, R49	RC20GF302J	RESISTOR, Carbon $\frac{1}{2}$w, 5%, 3,000Ω	2	Stackpole
R19	RC20GF332K	RESISTOR, Carbon $\frac{1}{2}$w, 10%, 3,300Ω	1	Stackpole
R28, R31, R43, R46	RC20GF392K	RESISTOR, Carbon $\frac{1}{2}$w, 10%, 3,900Ω	4	Stackpole
R1, R3	RC20GF562K	RESISTOR, Carbon $\frac{1}{2}$w, 10%, 5,600Ω	2	Stackpole
R2, R4	RC20GF303J	RESISTOR, Carbon $\frac{1}{2}$w, 5%, 30,000Ω	2	Stackpole
R5	RC20GF104J	RESISTOR, Carbon $\frac{1}{2}$w, 5%, 100,000Ω	1	Stackpole

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
R10, R11, R14, R18	RN65D	RESISTOR, Metal Film $\frac{1}{2}$w, 1%, 49.9Ω	4	Corning
R24, R33, R39, R47	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 100Ω	4	Corning
R26, R40	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 2,000Ω	2	Corning
R34, R49	RN60D	RESISTOR, Metal Film $\frac{1}{4}$w, 1%, 2,870Ω	2	Corning
R12, R25, R41	FR251M	POTENTIOMETER 250Ω	3	Allen Bradley
C7, C8	DD102	CAPACITOR, Ceramic 1000v, 0.001μf	2	CRL
C5, C6	CK103	CAPACITOR, Ceramic 50v, 0.01μf	2	CRL
C3, C4	WMF1P1	CAPACITOR, Mylar 100v, 0.1μf	2	CDE
C1, C2	34-750-1000-35T	CAPACITOR, Electrolytic, 35v, 1000μf	2	Richey
CR1 thru CR9	SCE-1	DIODE	9	Semtech
Q3, Q7, Q9, Q11, Q13, Q15 & Q16, Q17, Q18 & Q19, Q22, Q25	2N3638	TRANSISTOR	12	Fairchild
Q1, Q6, Q14, Q20	2N3642	TRANSISTOR	4	Fairchild
Q10 & Q12, Q23 & Q24	2N5134	TRANSISTOR	2	Fairchild
Q4, Q21	2N3740	TRANSISTOR	2	Motorola
Q2, Q13	40250	TRANSISTOR	2	RCA

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
	110-SW1-2	SWITCH, Wafer	2	Wavetek
	112-122	CIRCUIT BOARD, 1/16 Epoxy, 2oz. Copper	1	Wavetek
	BATTERY PACK PARTS LIST (112-023)			
	CH1.2T	BATTERY, Nickel Cadmium	16	Eveready
	112-123	CIRCUIT BOARD, 1/16 Epoxy, 2oz. Copper	1	Wavetek
	112-124	CIRCUIT BOARD, 1/16 Epoxy, 2oz. Copper	1	Wavetek

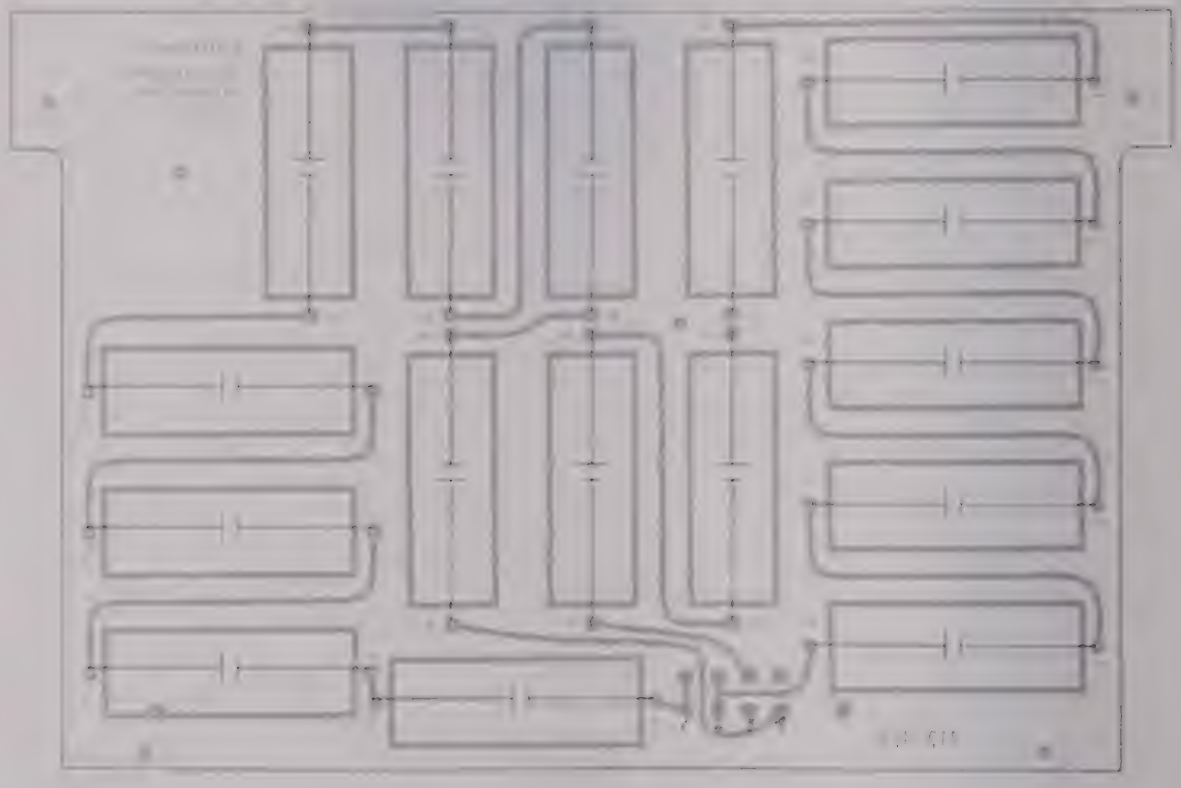


Figure 5-8
Battery Pack Assembly (112-023)

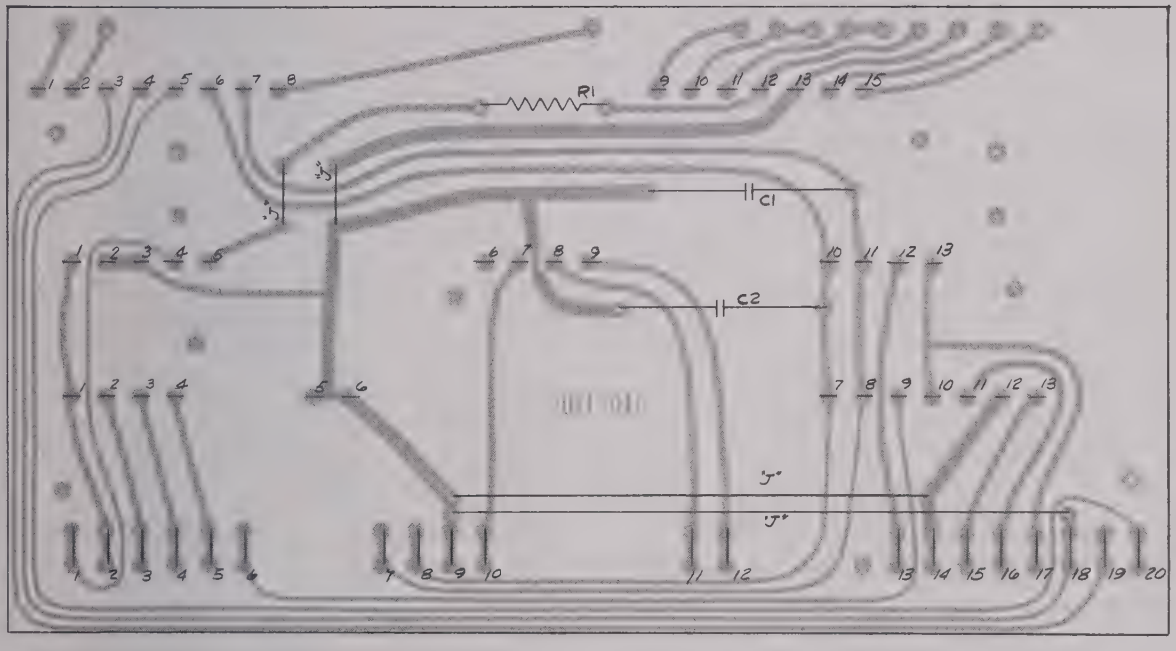


Figure 5-9
Mother Board Assembly (111-010)

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
R1*	RC32GF471K	RESISTOR, Carbon 1w, 10%, 47Ω	1	Stackpole
C1, C2	16-375-100-15T	CAPACITOR, Electrolytic, 15v, 100μf	2	Richey
	111-110	CIRCUIT BOARD, 1/16 Epoxy, 2oz. Copper	1	Wavetek

*Not used on battery models.

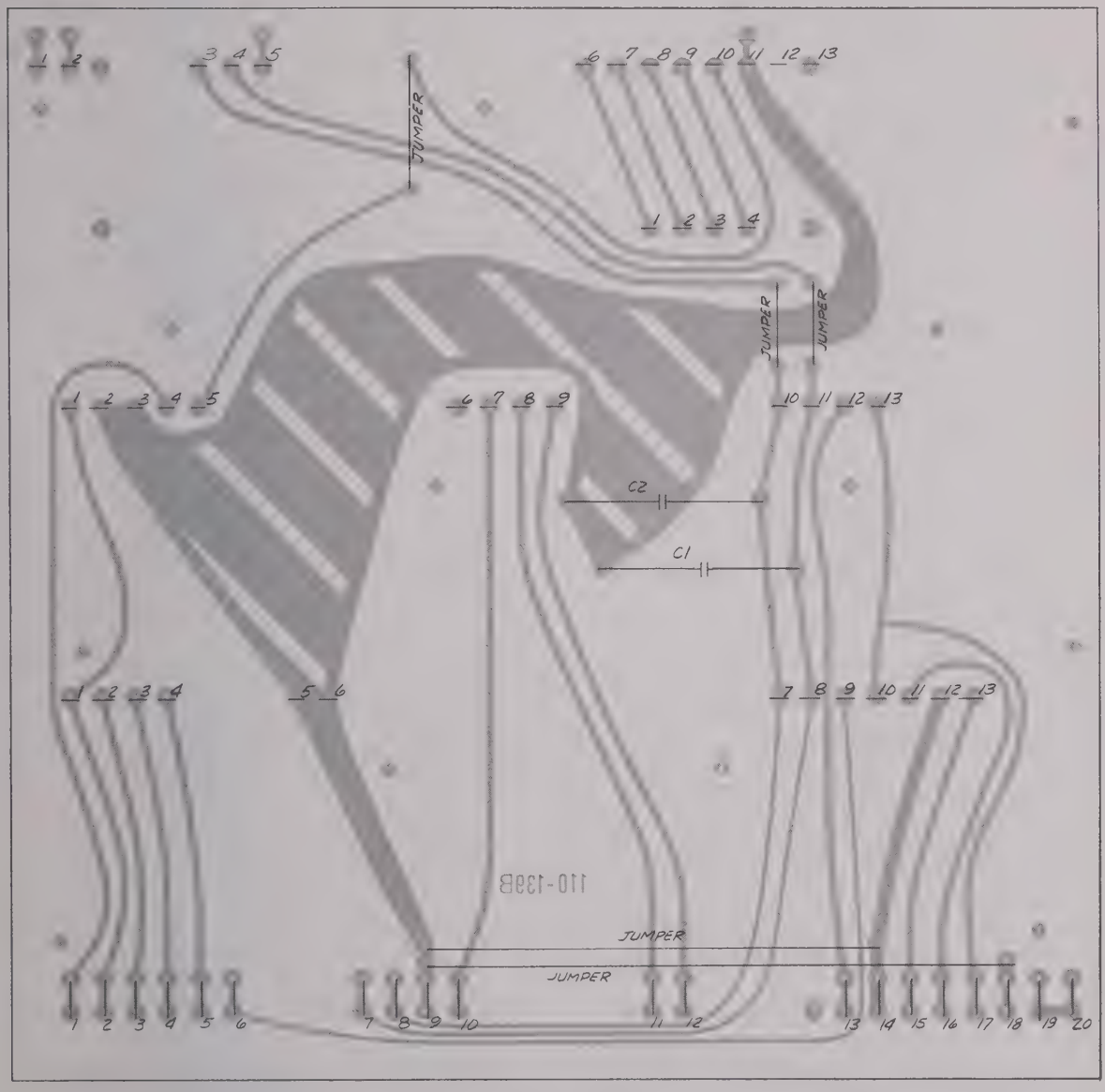
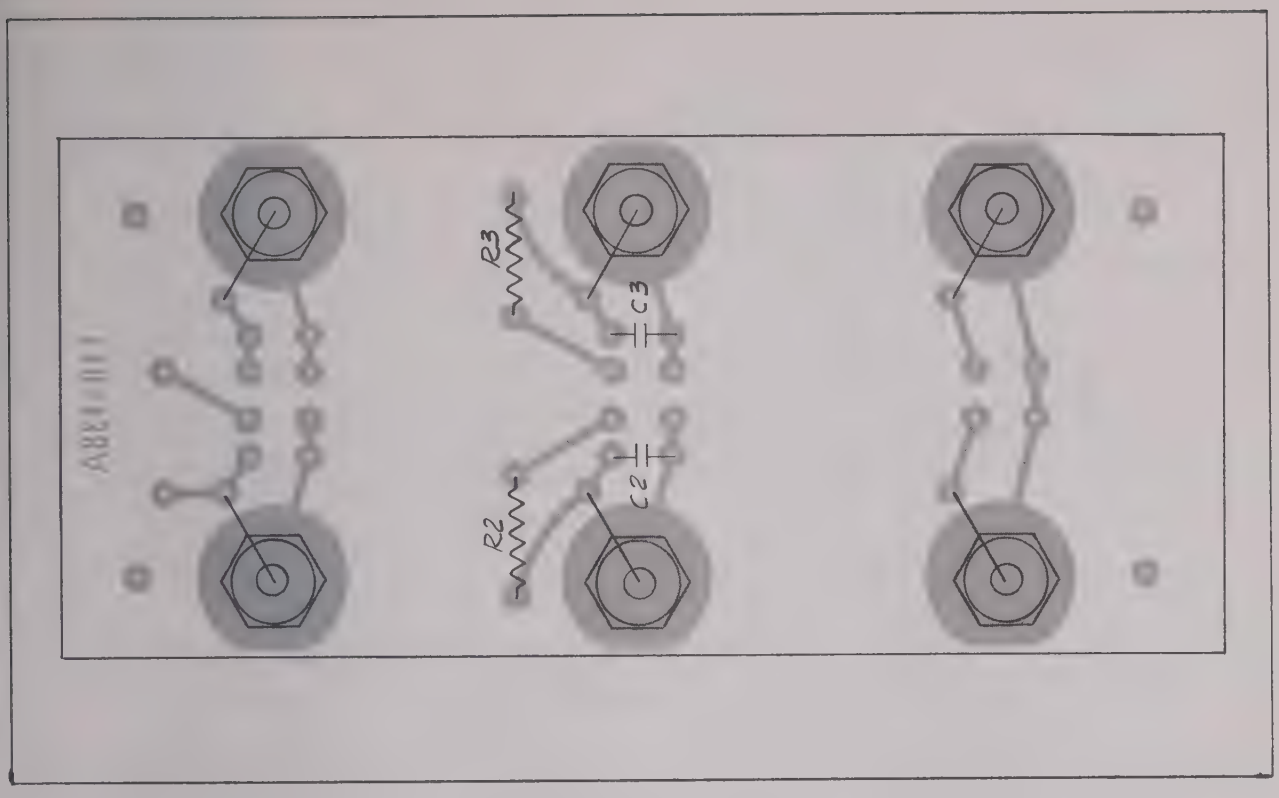
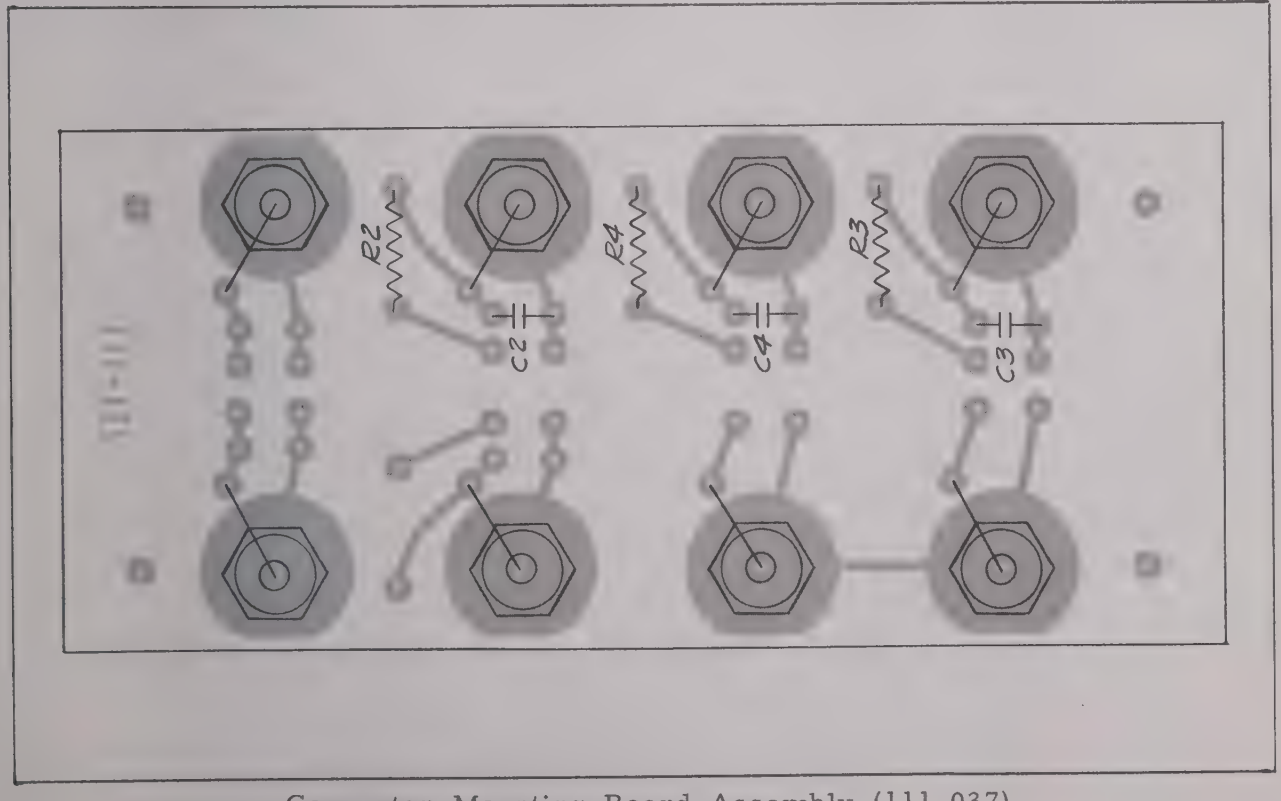


Figure 5-10
Mother Board Assembly (110-039)

CIRCUIT REFERENCE	PART NO.	DESCRIPTION	QTY	MFR
C1 C2	16-375-100-15T	CAPACITOR, Electrolytic, 15v, 100μf	2	Richey
	110-139	CIRCUIT BOARD, 1/16 Epoxy, 2oz. Copper	1	Wavetek



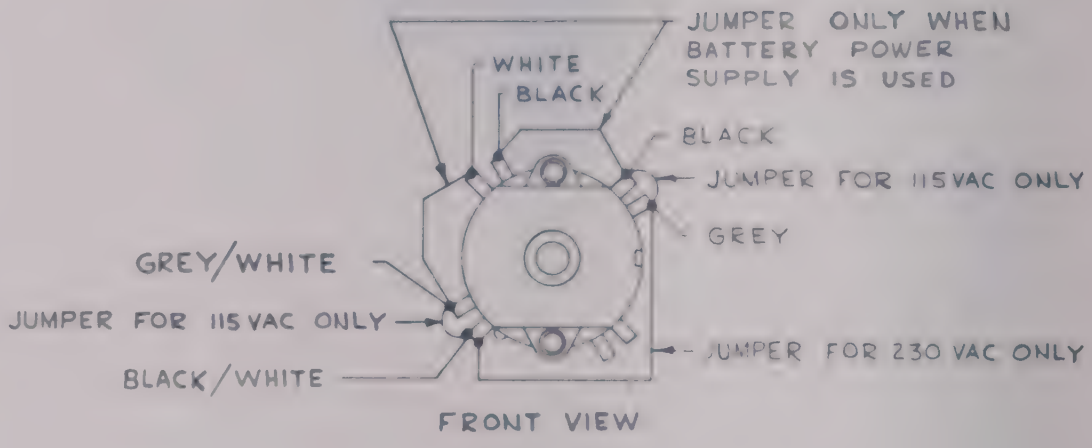
Connector Mounting Board Assembly (110-038)
(Rackmount Only)



Connector Mounting Board Assembly (111-037)
(Rackmount Only)
Figure 5-11

CIRCUIT REFERANCE	PART NO.	DESCRIPTION	QTY	MFR
CONNECTOR MOUNTING BOARD PARTS LIST (110-038)				
R2, R3	RN60D	RESISTOR, Metal Film ¼w, 1%, 49.9Ω	2	Corning
C1	DD101	CAPACITOR, Ceramic 1000v, 100pf	1	CRL
C2	DD681	CAPACITOR, Ceramic 1000v, 680pf	1	CRL
	UG657/U	CONNECTOR, BNC	6	Kings
	110-138	CIRCUIT BOARD, 1/16 Epoxy, 2oz. Copper	1	Wavetek
CONNECTOR MOUNTING BOARD PARTS LIST (111-037)				
R1, R3, R4	RN60D	RESISTOR, Metal Film ¼w, 1%, 49.9Ω	3	Corning
C4	DD101	CAPACITOR, Ceramic 1000v, 100pf	1	CRL
C1, C3	DD681	CAPACITOR, Ceramic 1000v, 680pf	2	CRL
	UG657/U	CONNECTOR, BNC	8	Kings
	111-137	CIRCUIT BOARD, 1/16 Epoxy, 2oz. Copper	1	Wavetek

SECTION VI
SCHEMATIC DIAGRAMS



115/230 V SWITCH WIRING

115/230 VAC Switch Wiring Schematic Diagram

MANUAL REVISIONS

Since printing and delivery schedules sometimes do not coincide with engineering developments, the most current data may not appear in its proper place in the printed manual. The following pages are therefore provided.

MODEL 110 - 116:

Raytheon 2N2905 may be used as an alternate for TI 2N2905.

VCG BOARD:

1. Change R45, 160Ω carbon resistor to 47Ω, 10% carbon resistor.
2. Change C3, .001μf ceramic disc capacitor to .0015μf ceramic disc capacitor.

POWER SUPPLY BOARD:

1. Change R33, 3.83K metal film resistor to 3.32K, 1% metal film resistor.
2. Change R36, 6.2K carbon resistor to 7.5K, 1% metal film resistor.
3. Change R38, 3.83K metal film resistor to 3.32K, 1% metal film resistor.
4. Change R44, 220Ω carbon resistor to 150Ω, 5% carbon resistor.

MODEL 110 FRONT SUBPANEL:

1. Change R22, 10K carbon resistor to 2K, 5% carbon resistor.
2. Change R24, 43Ω carbon resistor to 33Ω, 5% carbon resistor.
3. Change C11, 47pf ceramic disc capacitor to 100pf ceramic disc capacitor.
4. Change C12, 100pf ceramic disc capacitor to 68pf ceramic disc capacitor.
5. Delete C14.
6. Delete R36.
7. Add a 49.9Ω, 1%, metal film resistor in series with sine, triangle and square wave inputs at function selector switch.

   See Figure 1.

MODEL 111 FRONT SUBPANEL:

1. Change R35, 43Ω carbon resistor to 33Ω, 5%, carbon resistor.
2. Change R38, 10K carbon resistor to 2K, 5%, carbon resistor.
3. Change C12, 100pf ceramic disc capacitor to 68pf, ceramic disc capacitor.

4. Change C15, 47pf, ceramic disc capacitor to 100pf, ceramic disc capacitor.

5. Delete R57.

6. Delete C18.

7. Add a 49.9Ω, 1%, metal film resistor in series with sine, triangle, square and ramp inputs at the function selector switch.

   See Figure 2.

ALL BATTERY MODEL SPECIFICATIONS:

Square Wave Rise and Fall Time - delete "5 volt adjustable less than 100nsec."

VCG BOARD:

1. Model 111: Add C15, 5pf, ceramic disc capacitor in parallel with R12.

2. Model 112: Change C15, 100pf, ceramic disc capacitor to 5pf, ceramic disc capacitor.

3. Model 114: Delete C17 and add C15, 5pf, ceramic disc capacitor in parallel with R12.

TRIGGER BOARD: (Models 112, 114, 115 and 116)

1. Change R19, 1.1K, metal film resistor to a metal film trim resistor with a nominal value of 1.1K, 1%.

FRONT SUBPANEL: (Models 110B and 111B)

1. Delete 49.9Ω metal film resistors in series with sine, triangle and square (and ramp on 111B) wave inputs at the function selector switch.

GENERAL:

1. Change all 2N5134 transistors to 2N3646.

2. Change all 2N5141 transistors to 2N3640.

MODEL 110 AND 111:

1. Page 3-5, line 22, under OUTPUT AMPLIFIER should read: "When terminated in 50Ω, the amplifier will deliver 10 volts peak to peak maximum."

2. Delete the last two sentences of paragraph one under OUTPUT AMPLIFIER on page 3-5.

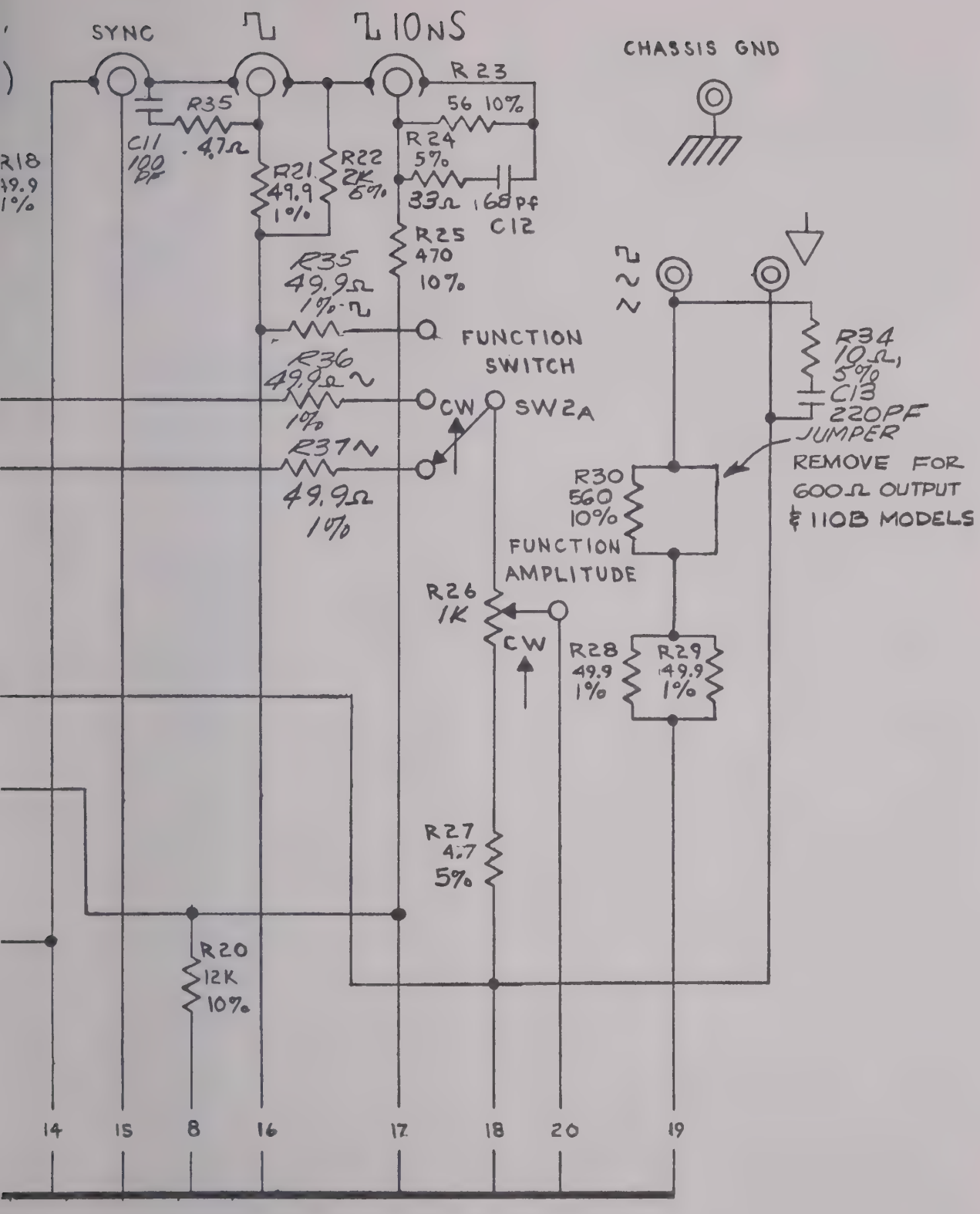

SYNC
10NS
CHASSIS GND
R23
56 10%
R24
5%
33Ω
68pf
C12
R35
4.7Ω
C11
100
pf
R18
49.9
1%
R21
49.9
1%
R22
2K
5%
R25
470
10%
R35
49.9Ω
1%
FUNCTION
SWITCH
R36
49.9Ω
1%
CW
SW2A
R37
49.9Ω
1%
R34
10Ω,
5%
C13
220PF
JUMPER
REMOVE FOR
600Ω OUTPUT
& 110B MODELS
R30
560
10%
FUNCTION
AMPLITUDE
R26
1K
CW
R28
49.9
1%
R29
49.9
1%
R27
4.7
5%
R20
12K
10%
14
15
8
16
17
18
20
19

Figure 1

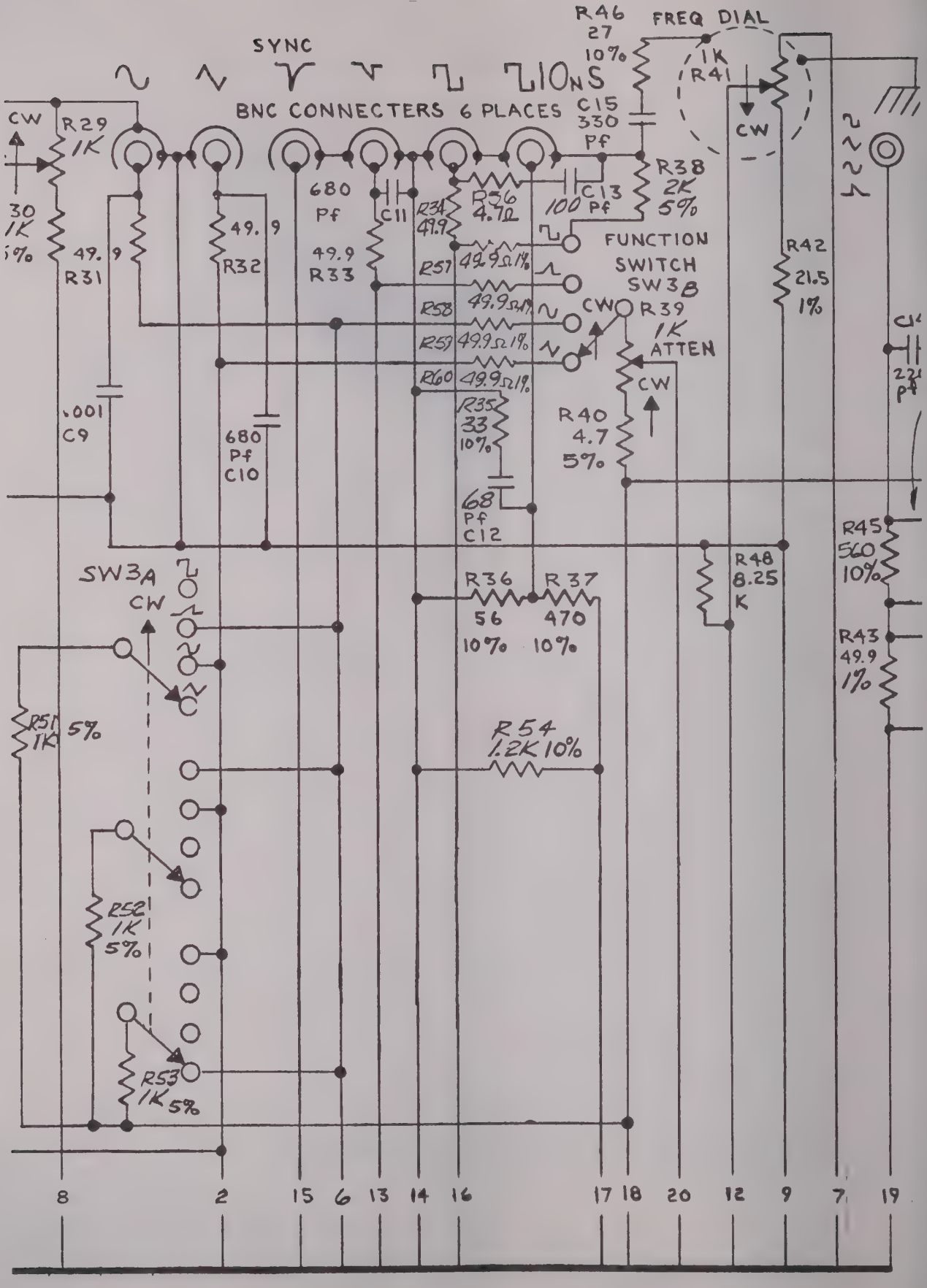
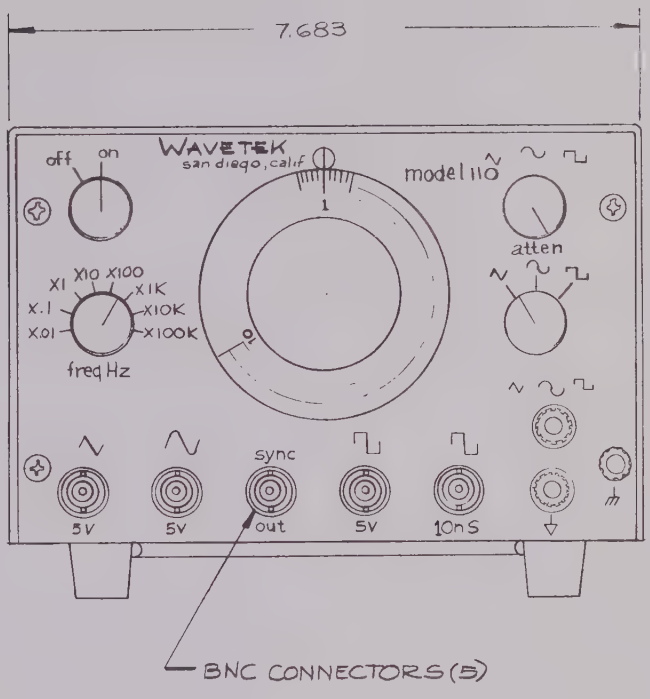
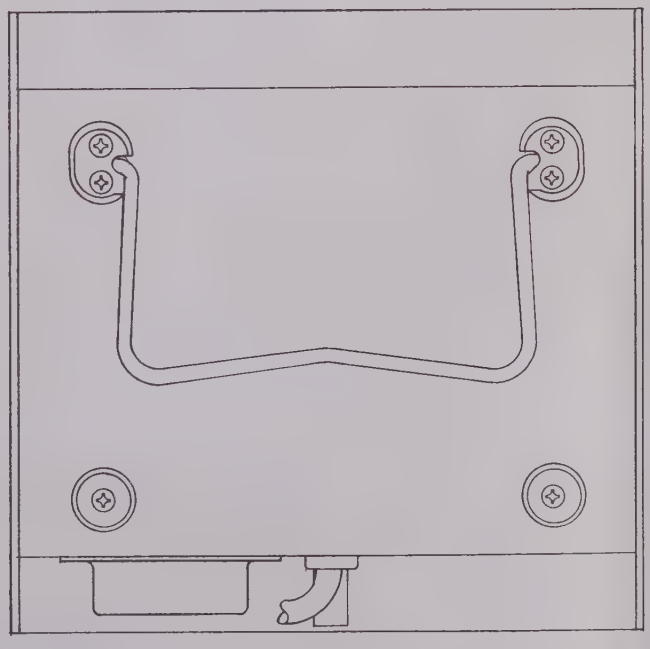
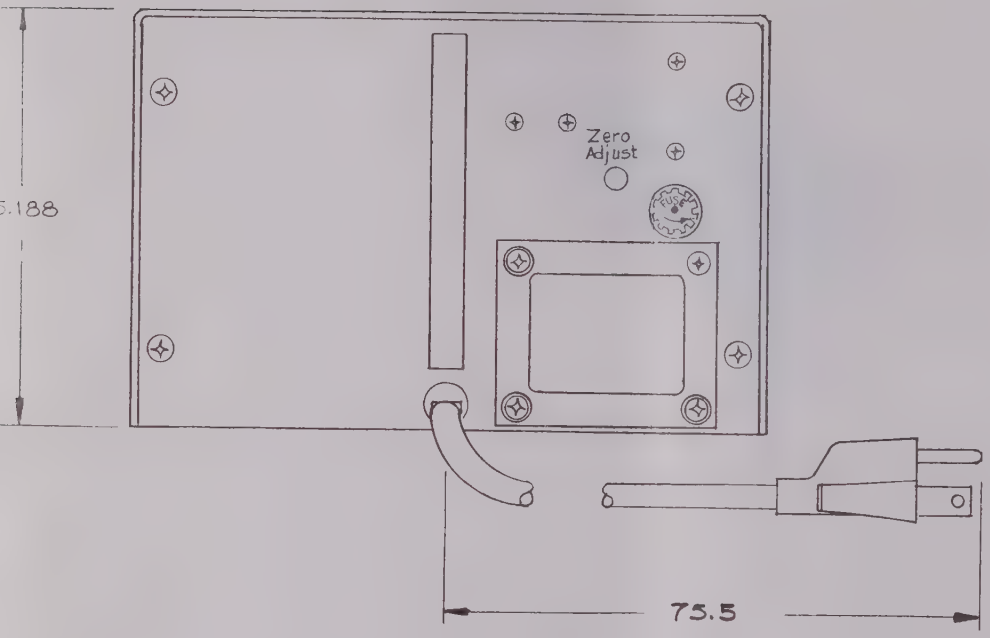

SYNC
BNC CONNECTERS 6 PLACES
R46 27 10%
FREQ DIAL
1K R41
CW
R29 1K
C15 330 Pf
R38 2K 5%
680 Pf C11
R34 49.9
R36 4.7Ω
C13 100 Pf
FUNCTION SWITCH SW3B
R57 49.9Ω 1%
R58 49.9Ω 1%
R59 49.9Ω 1%
R60 49.9Ω 1%
CW
R39 1K ATTEN
R42 21.5 1%
R40 4.7 5%
R35 33 10%
68 Pf C12
.001 C9
680 Pf C10
R31
R32
R33
SW3A
R36 56 10%
R37 470 10%
R48 8.25 K
R45 560 10%
R43 49.9 1%
R51 1K 5%
R54 1.2K 10%
R52 1K 5%
R53 1K 5%
8 2 15 6 13 14 16 17 18 20 12 9 7 19

Figure 2


7.683
WAVETEK
san diego, calif
model 110
off
on
atten
X1
X10
X100
X.1
X.01
X1K
X10K
X100K
freq Hz
sync
5V
5V
out
5V
10nS
BNC CONNECTORS (5)





REAR VIEW

7.495

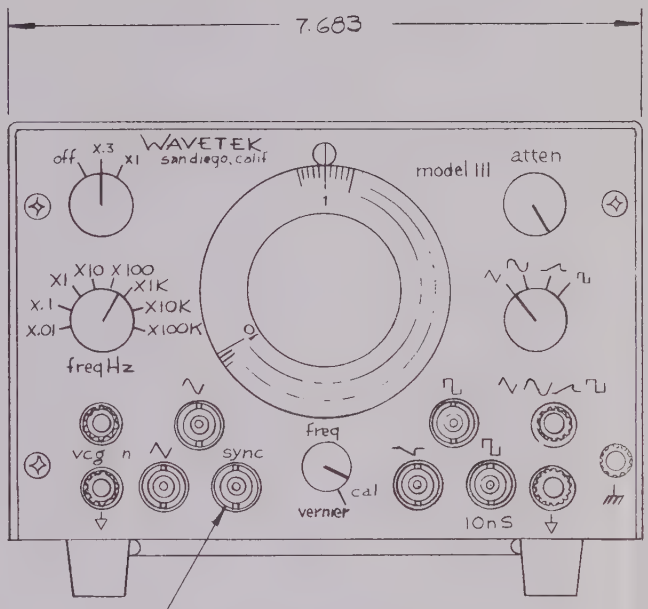
A	117	L Eidanson	4/7/67	
REV	ECN	BY	DATE	APP'D

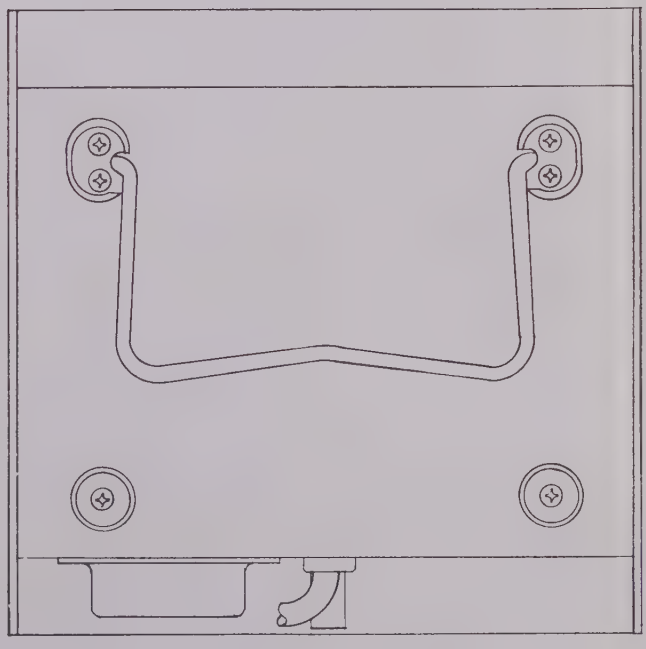
WAVETEK 8159 ENGINEER RD SAN DIEGO, CALIF

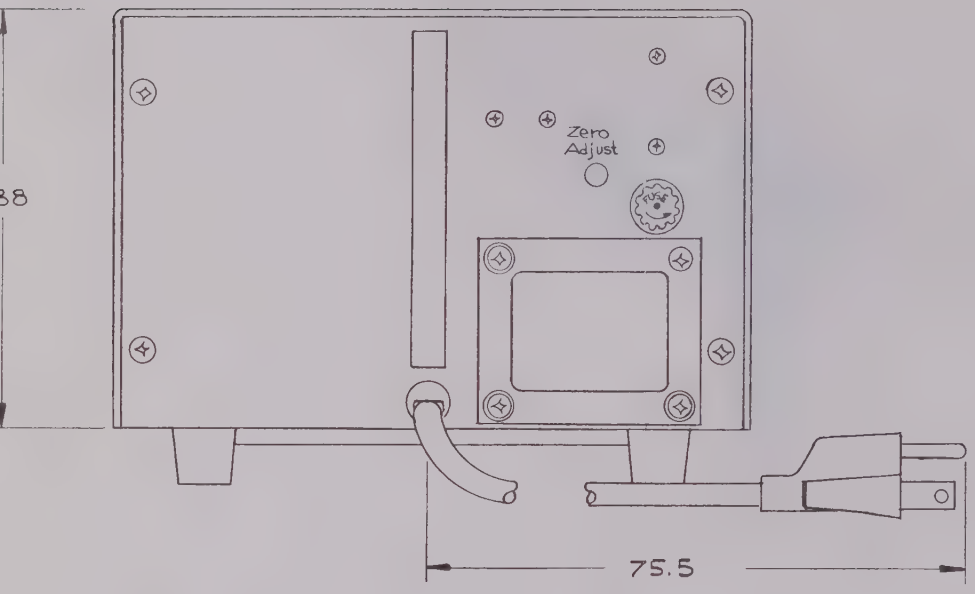
DWN: J. WHITELOCK DATE: 3-14-6 APP'D: P. Macke

OUTLINE DRAWING

MODEL: 110, 110B NO: 110-600 A


7.683
WAVETEK
san diego, calif
model III
atten
off
x.3
x1
x.1
x.01
x10
x100
x1K
x10K
x100K
freq Hz
freq
cal
vernier
sync
vcg
n
10nS
BNC CONNECTORS (6)





REAR VIEW

7.495

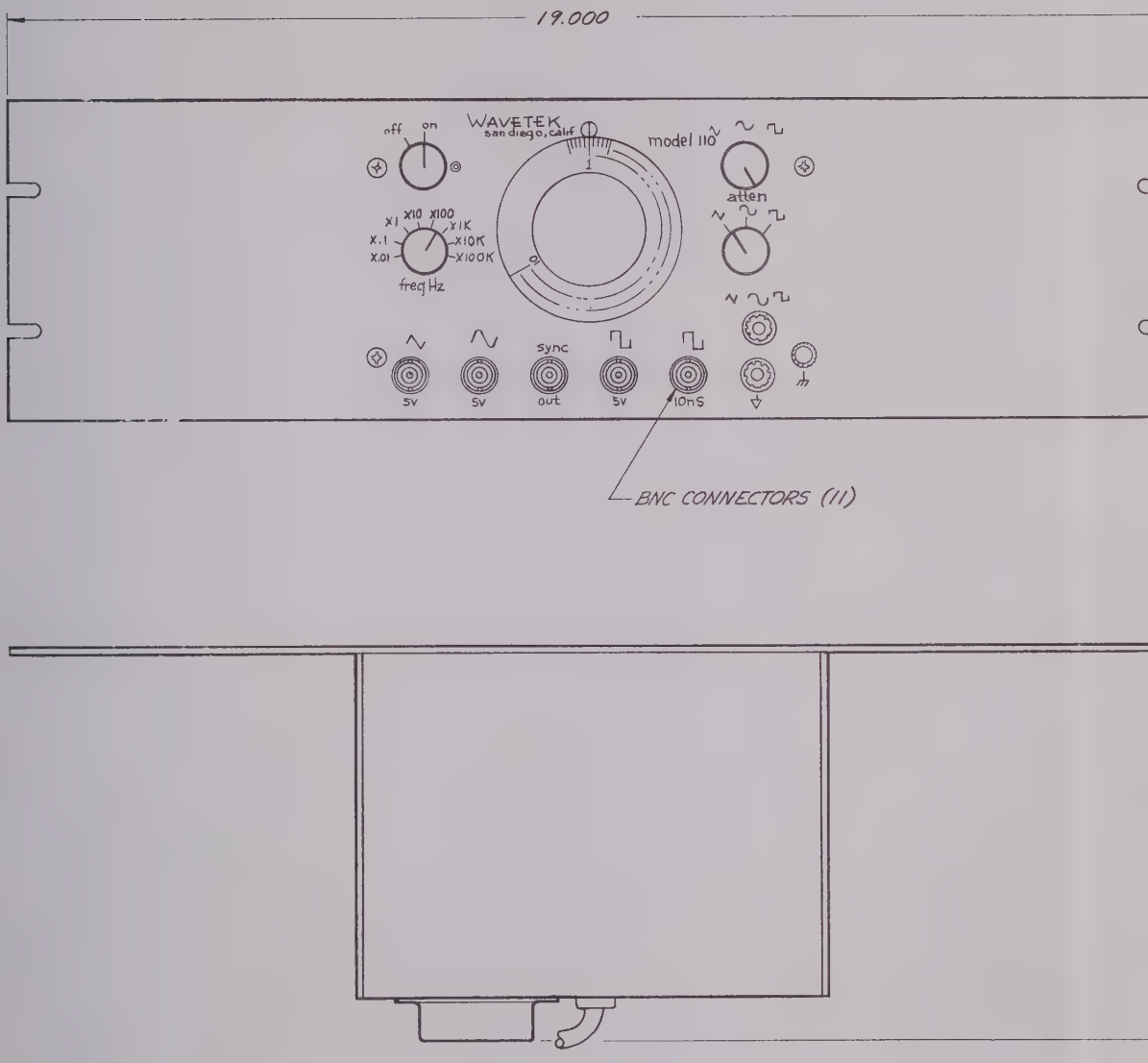
A	117	L Adamson	4/7/67	
REV	ECN	BY	DATE	APP'D

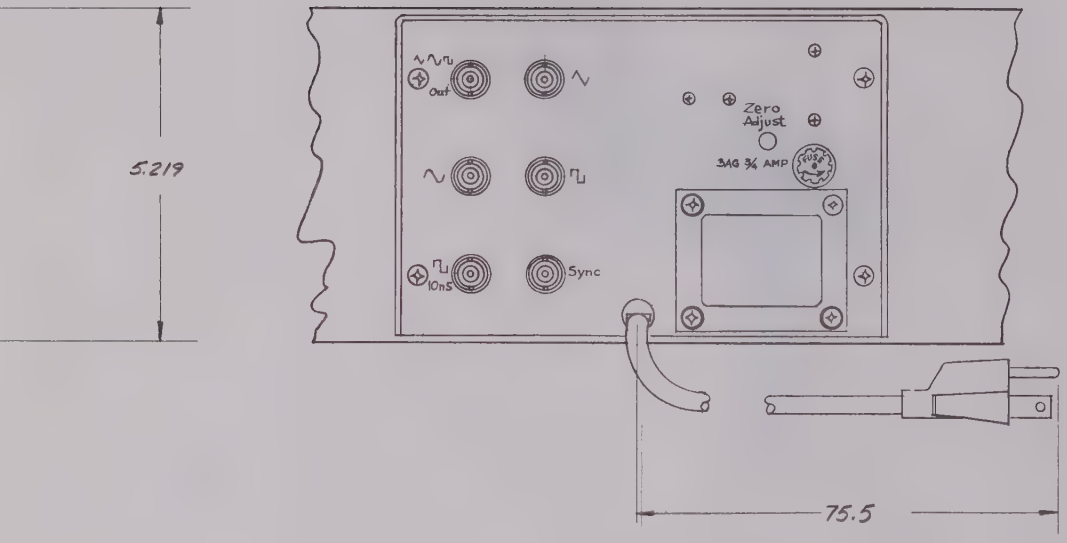
WAVETEK 8159 ENGINEER RD SAN DIEGO 23, CALIF.

DWN: J. WHITELOCK DATE: 3-14-6 APP'D: P. Mackie

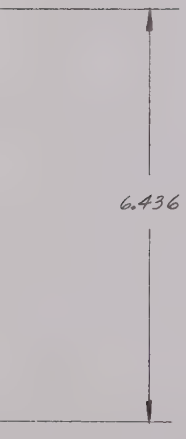
OUTLINE DRAWING

MODEL: 111, 111B NO: 111-600 A

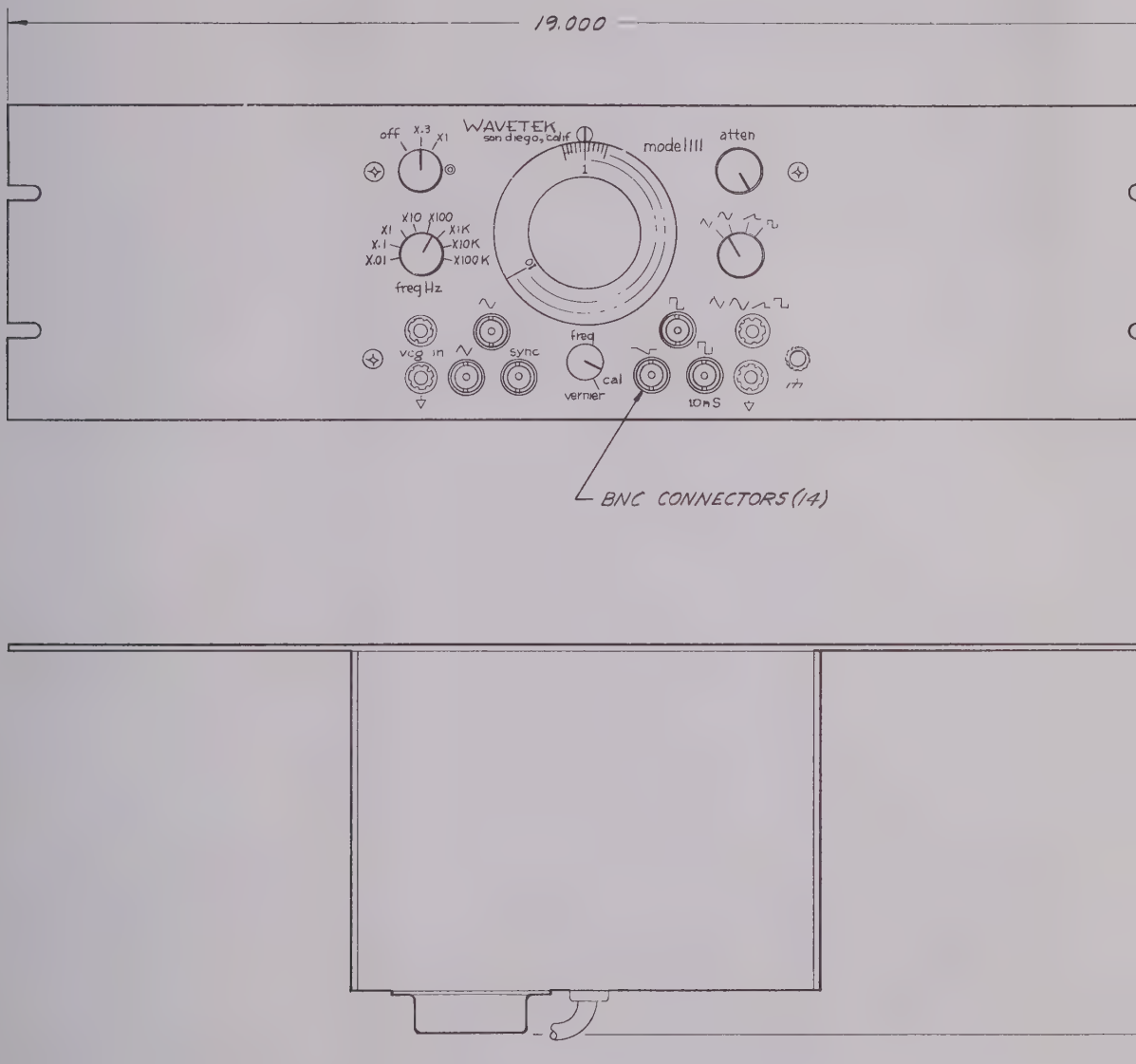

19.000
off
on
WAVETEK
san diego, calif
model 110
atten
X1
X10
X100
X1K
X10K
X100K
X.1
X.01
freq Hz
sync
5v
5v
out
5v
10nS
BNC CONNECTORS (11)

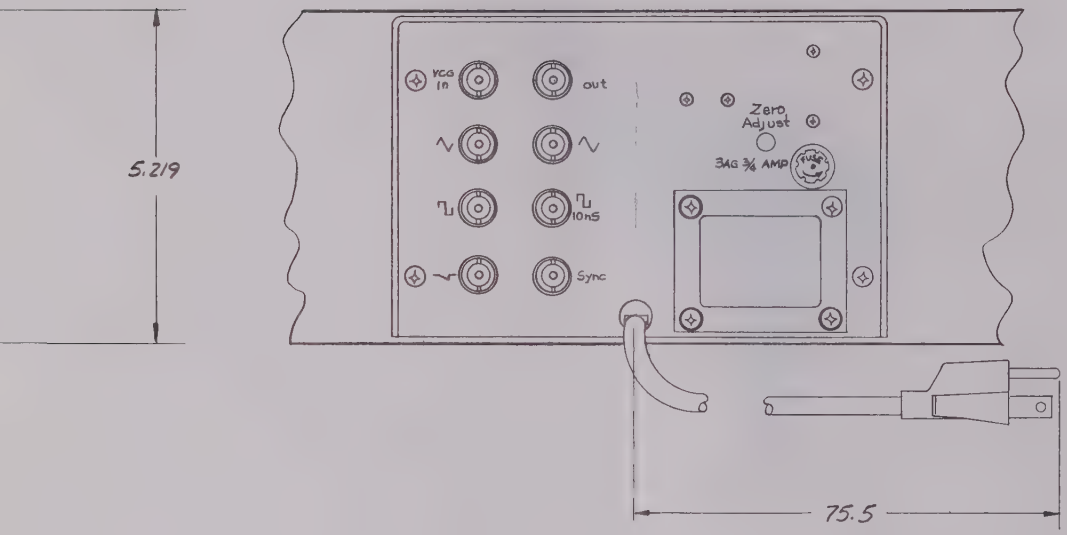


REAR VIEW



WAVETEK	8159 ENGINEER RD SAN DIEGO, CALIF	
DWN: WHITELOCK	DATE: 7-14-6	APP'D: P. Mackie
OUTLINE DWG. - RACK MOUNT		
MODEL: 110, 110B		NO: 110-601

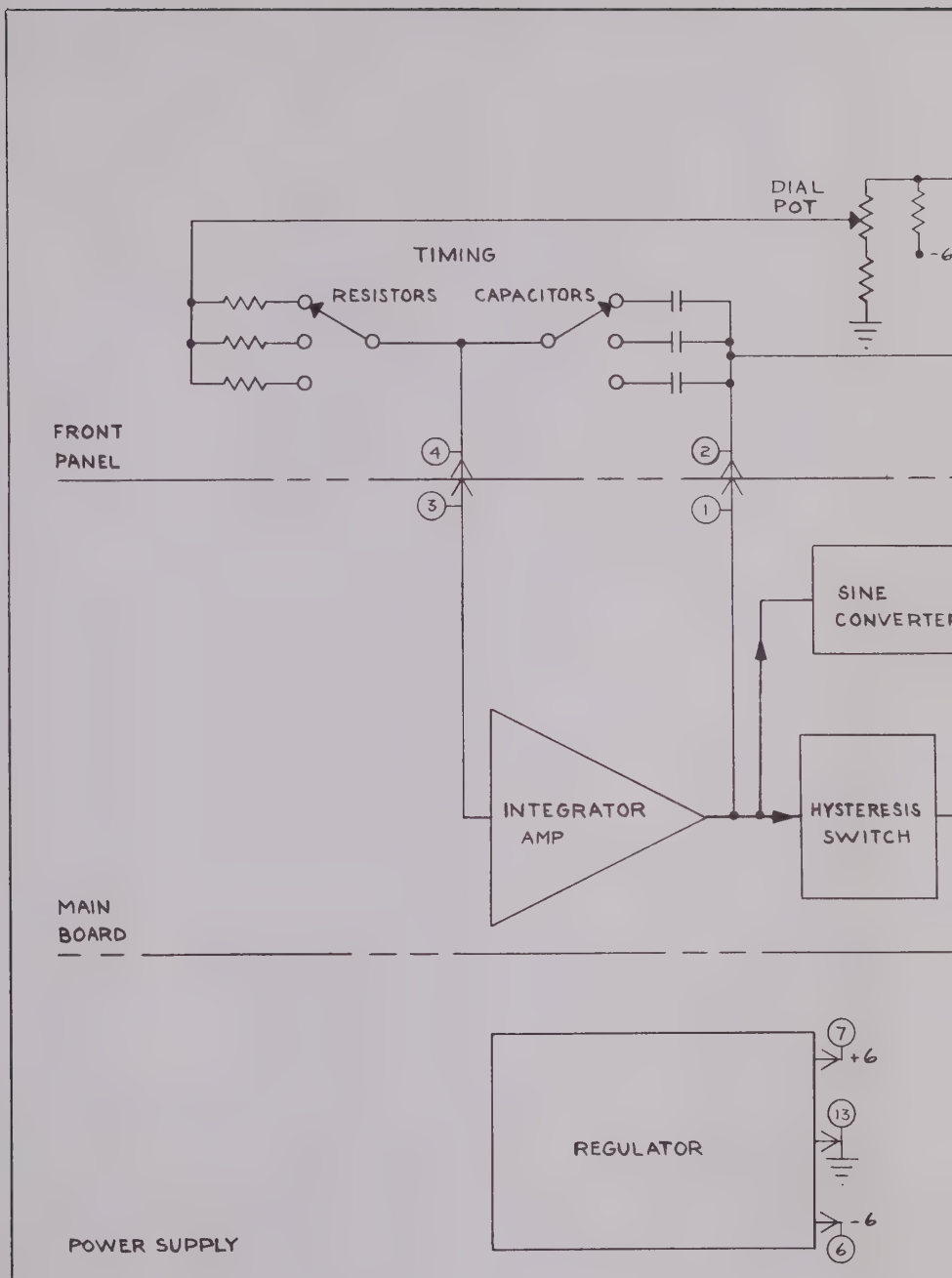

19.000
WAVETEK
san diego, calif
model 111
off
x.3
x1
atten
x10
x100
x1
x.1
x.01
x1K
x10K
x100K
freq Hz
vcg in
sync
freq
cal
vernier
10mS
BNC CONNECTORS (14)



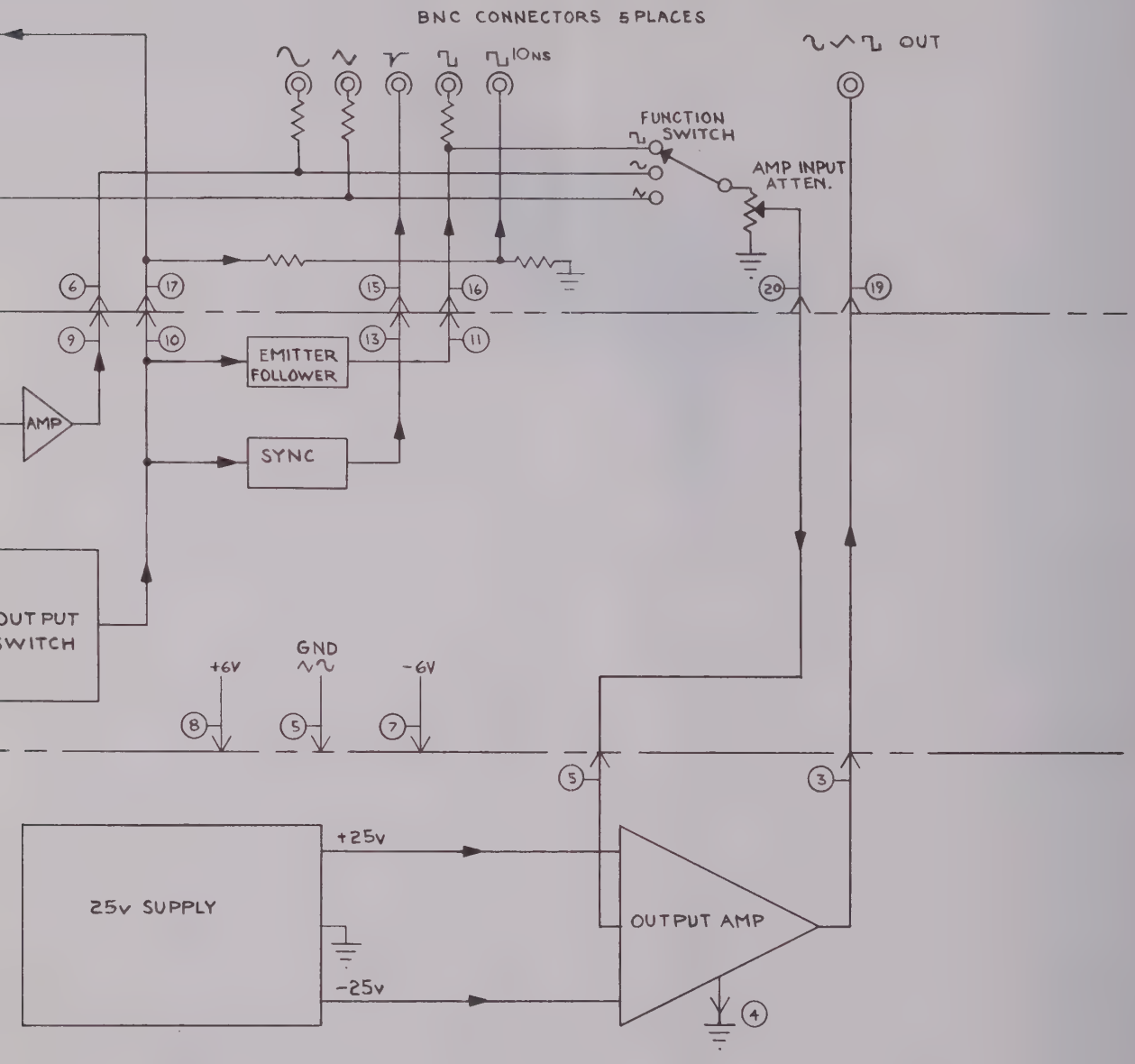
REAR VIEW

6.436

WAVETEK		8159 ENGINEER RD. SAN DIEGO, CALIF
DWN: WHITELOCK	DATE: 4-14-6	APP'D: P. Mauhi
OUTLINE DWG.- RACK MOUNT		
MODEL: 111, 111B		NO: 111-601



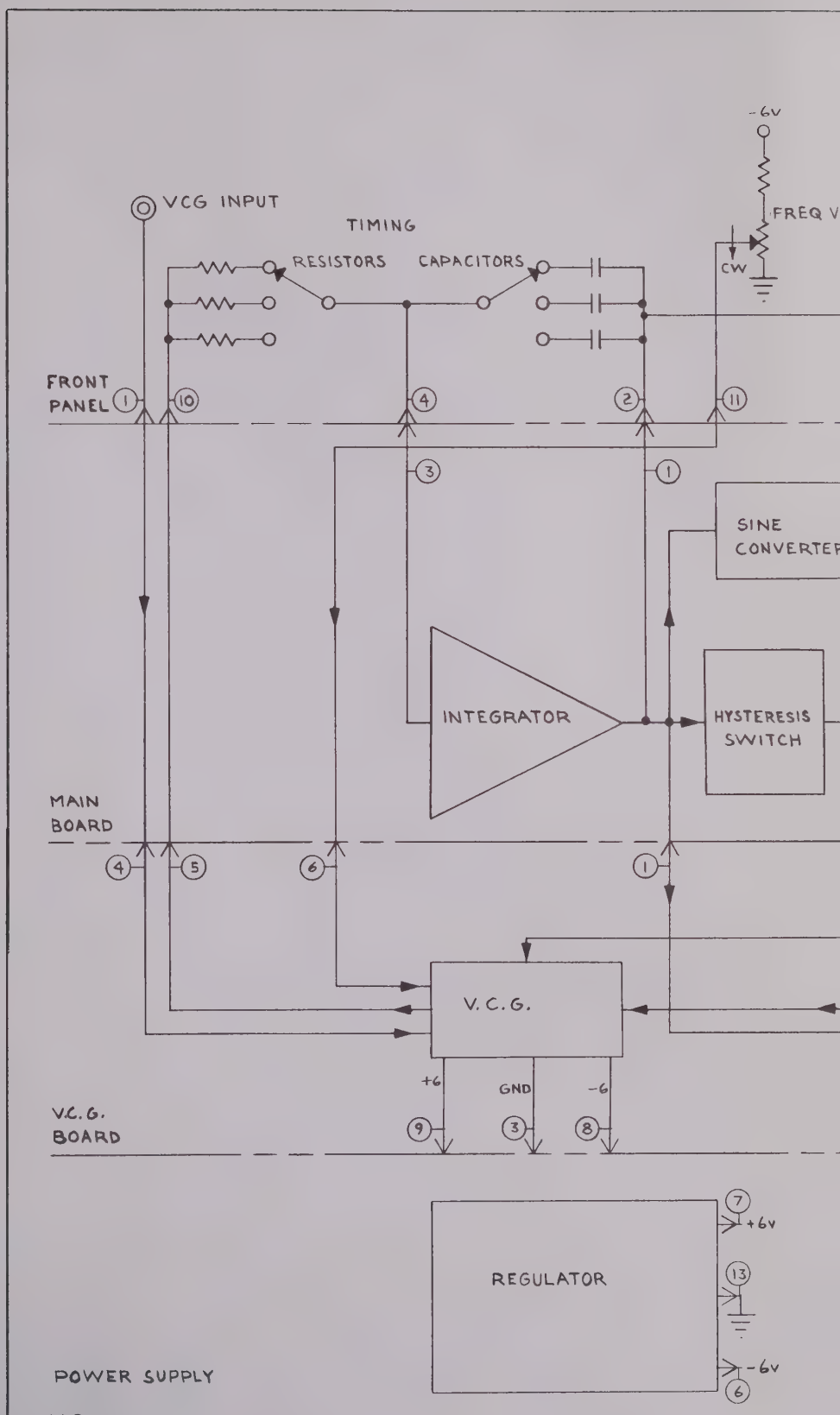
NOTE:
NUMBERED CONNECTIONS ARE FROM NUMBER OF PIN ON BOARD INDICATED TO MOTHER BOARD



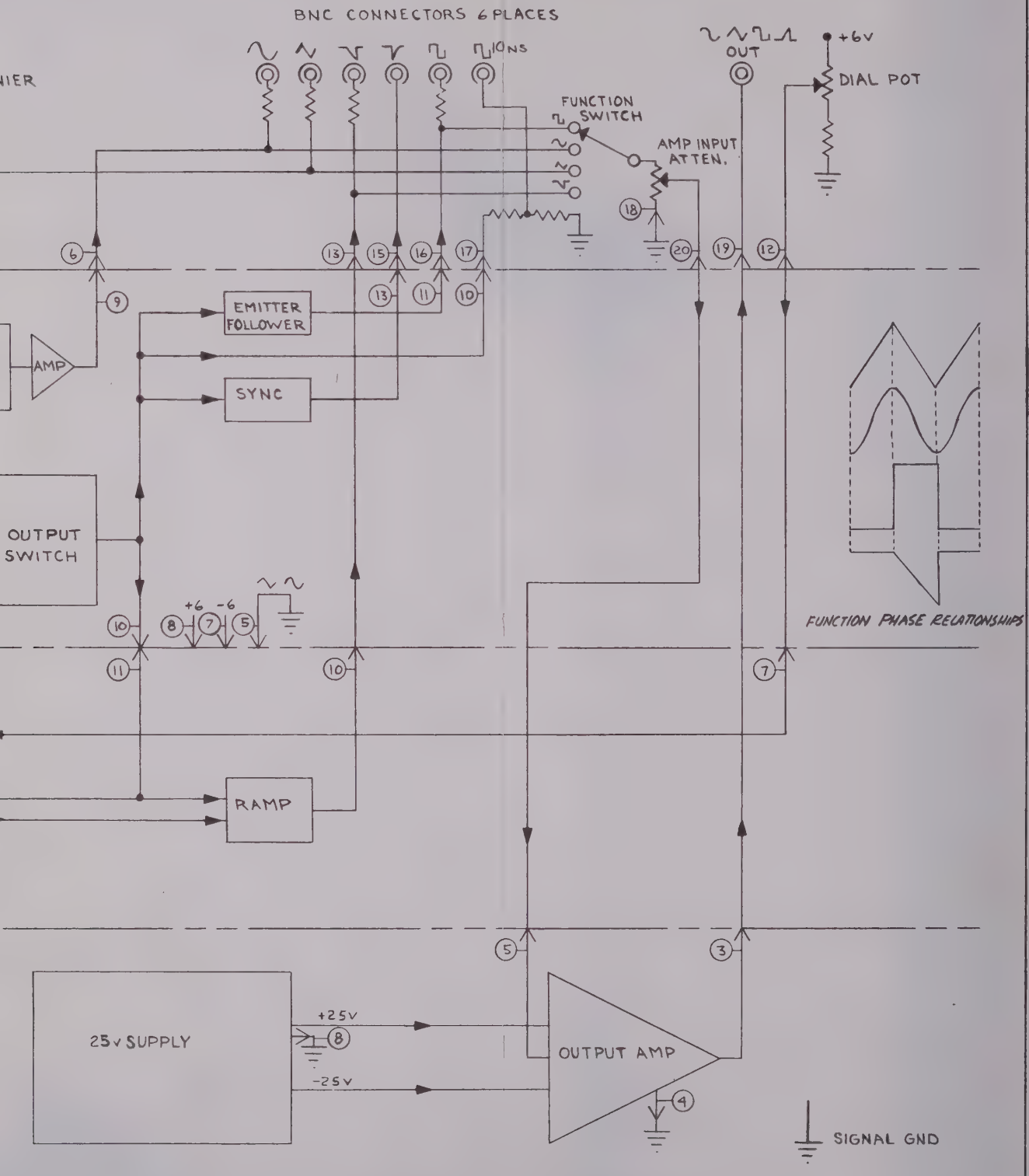
FUNCTION PHASE RELATIONSHIPS

BLOCK DIAGRAM
MODEL 110
DEC 30, 1965
DRN - P.A.M.
APP'D - Pm

NO.
110-602

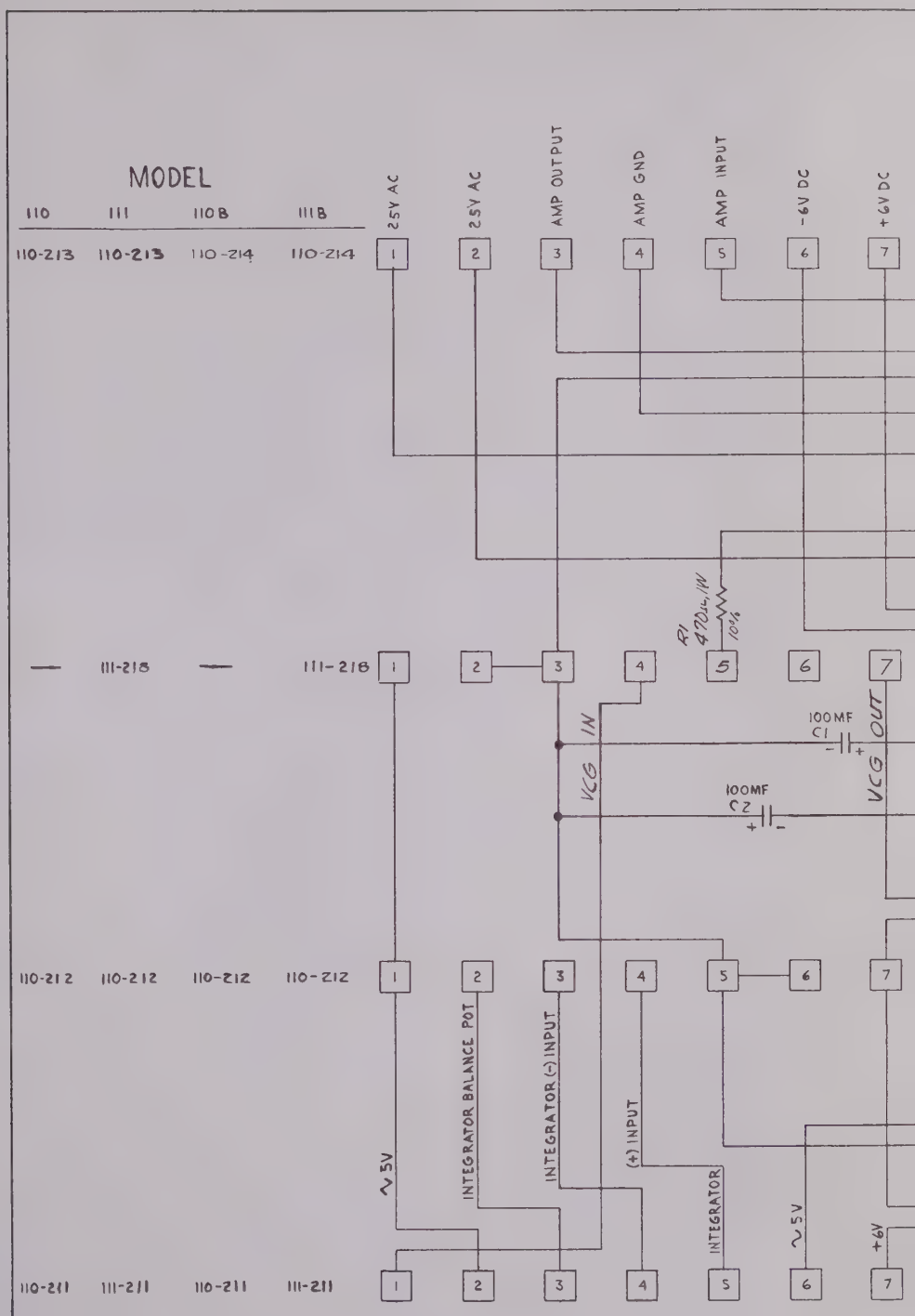


NOTE:
NUMBERED CONNECTIONS ARE FROM NUMBER OF PIN ON BOARD INDICATED TO MOTHER BOARD



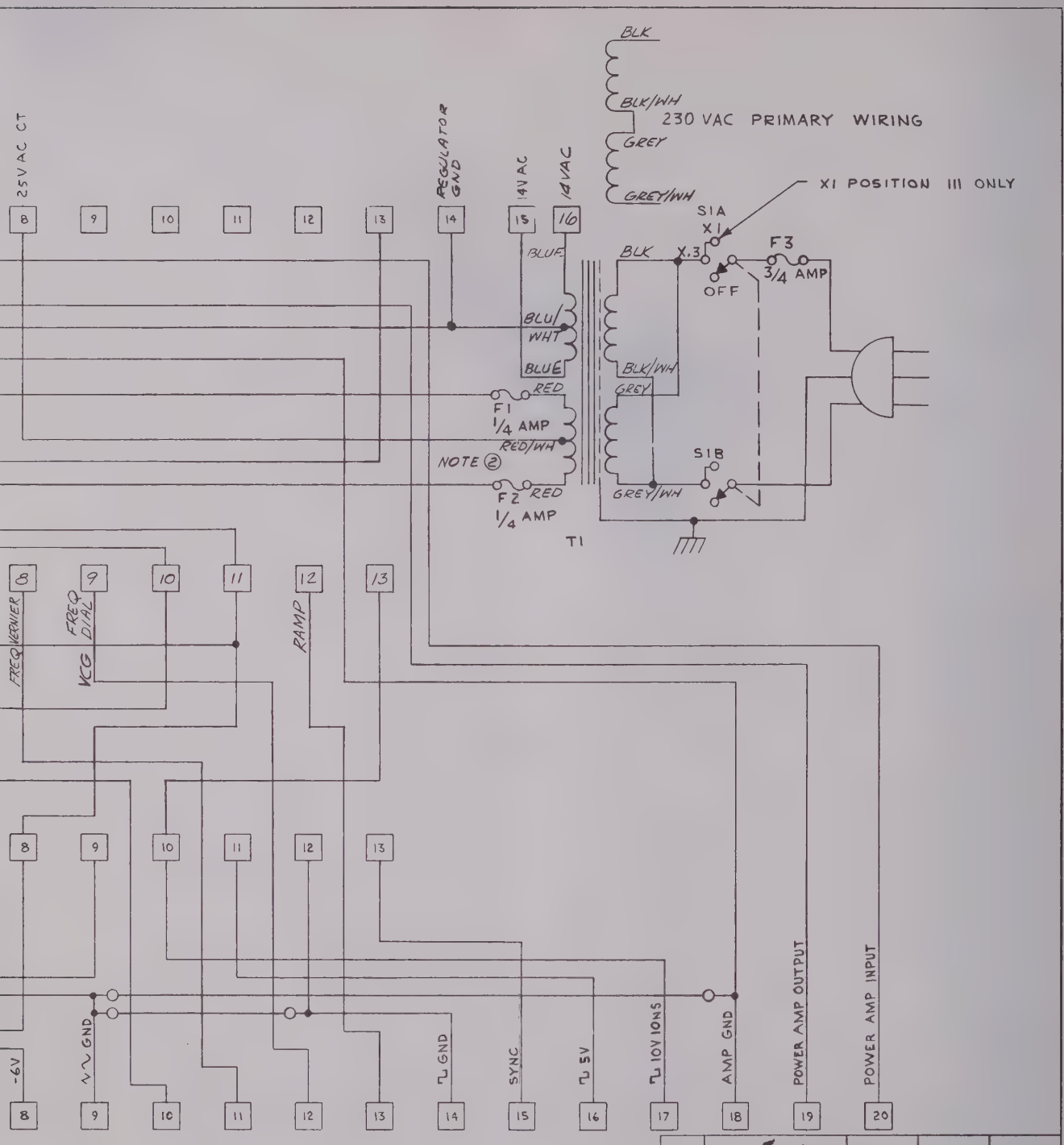
BLOCK DIAGRAM
MODEL III
DEC 30, 1965
DRN - P.A.M. APP'D - PM

NO. 111-602



NOTE

1. PINS ARE NUMBERED FROM LEFT TO RIGHT AS VIEWED FROM COMPONENT SIDE OF CIRCUIT BOARD.



FRONT

B	ECN # 146	MEB	6-21-67	
A	ECN #94 (WAS DWG # 110-200B)	JW	12-12-66	
CHG	ECN NO	BY	DATE	APP

WAVETEK
8159 ENGINEER RD
SAN DIEGO, CALIF

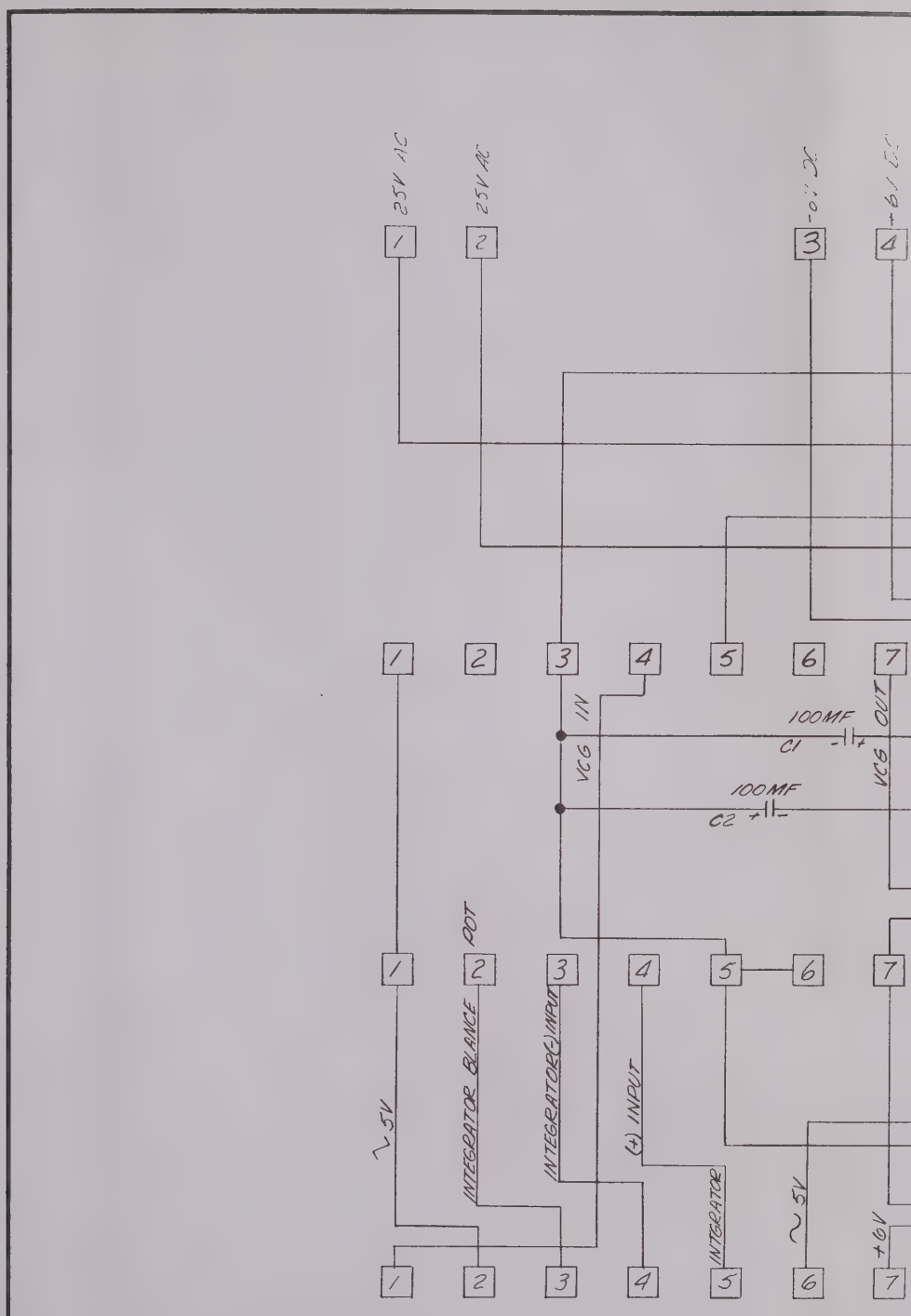
DRN PA Marsh DATE 1-20-66 APP P. MacKie

MOTHER BOARD

D	REVISED		2/1/68
C	ECN 162		8/8/67

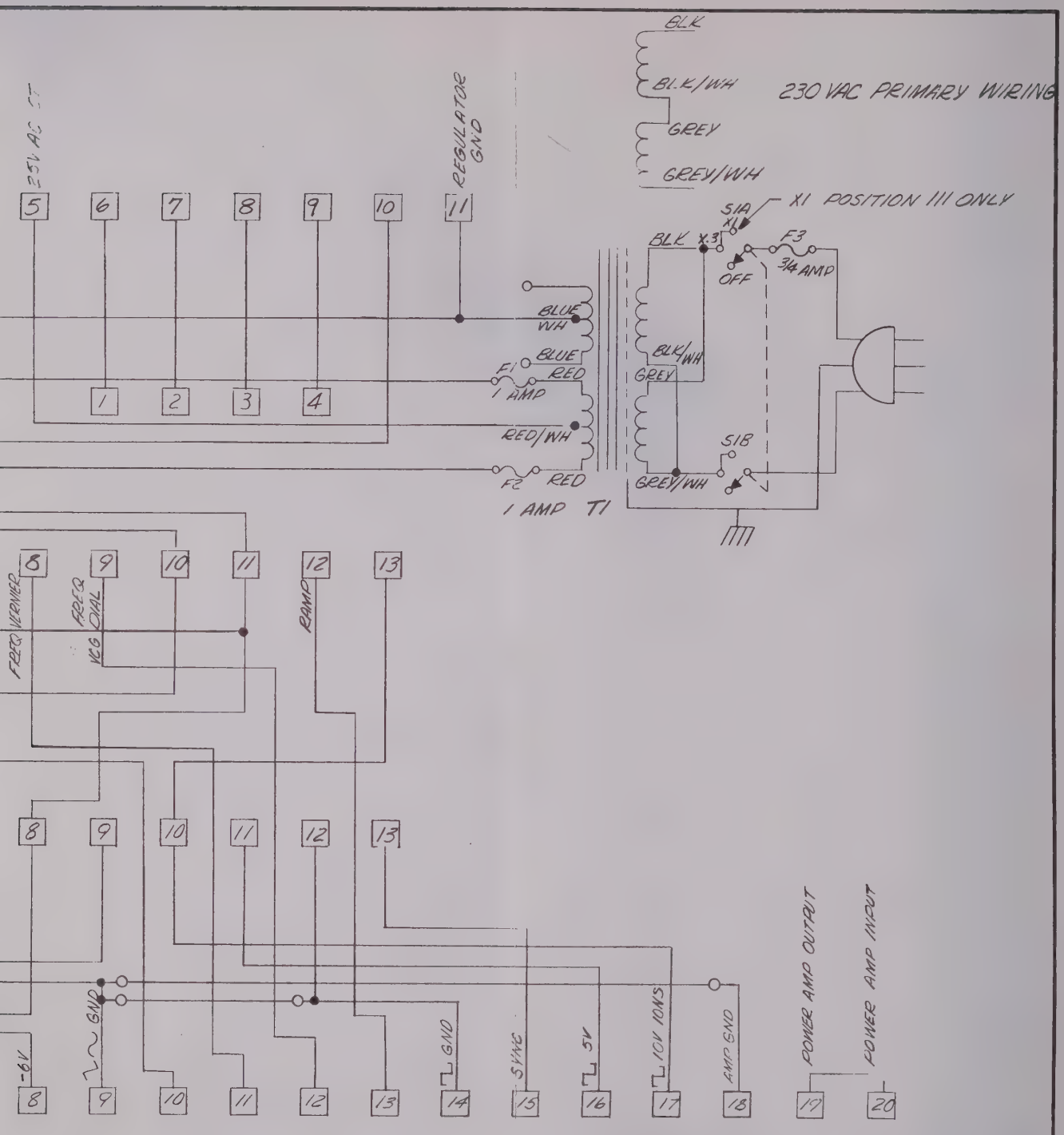
MODEL 110 - 111

NO. 110-210D



NOTES:

1. PINS ARE NUMBERED FROM LEFT TO RIGHT AS VIEWED FROM COMPONENT SIDE OF CIRCUIT BOARD



B	PIN CORRECTION	MEB	1/22/67	
A	ECN #167	ENH	9-5-67	
CHG	ECN NO.	BY	DATE	APP

tolerance unless otherwise specified	rev	ecn	by	date	app.
.XXX ± .010 .XX ± .030	WAVETEK san diego, calif				
scale	by ENH	date 8-14-67	app P.M. Acker		
material	title MOTHER BOARD				
finish	model no. 110B, 111B	dwg no. 110-239	rev B		

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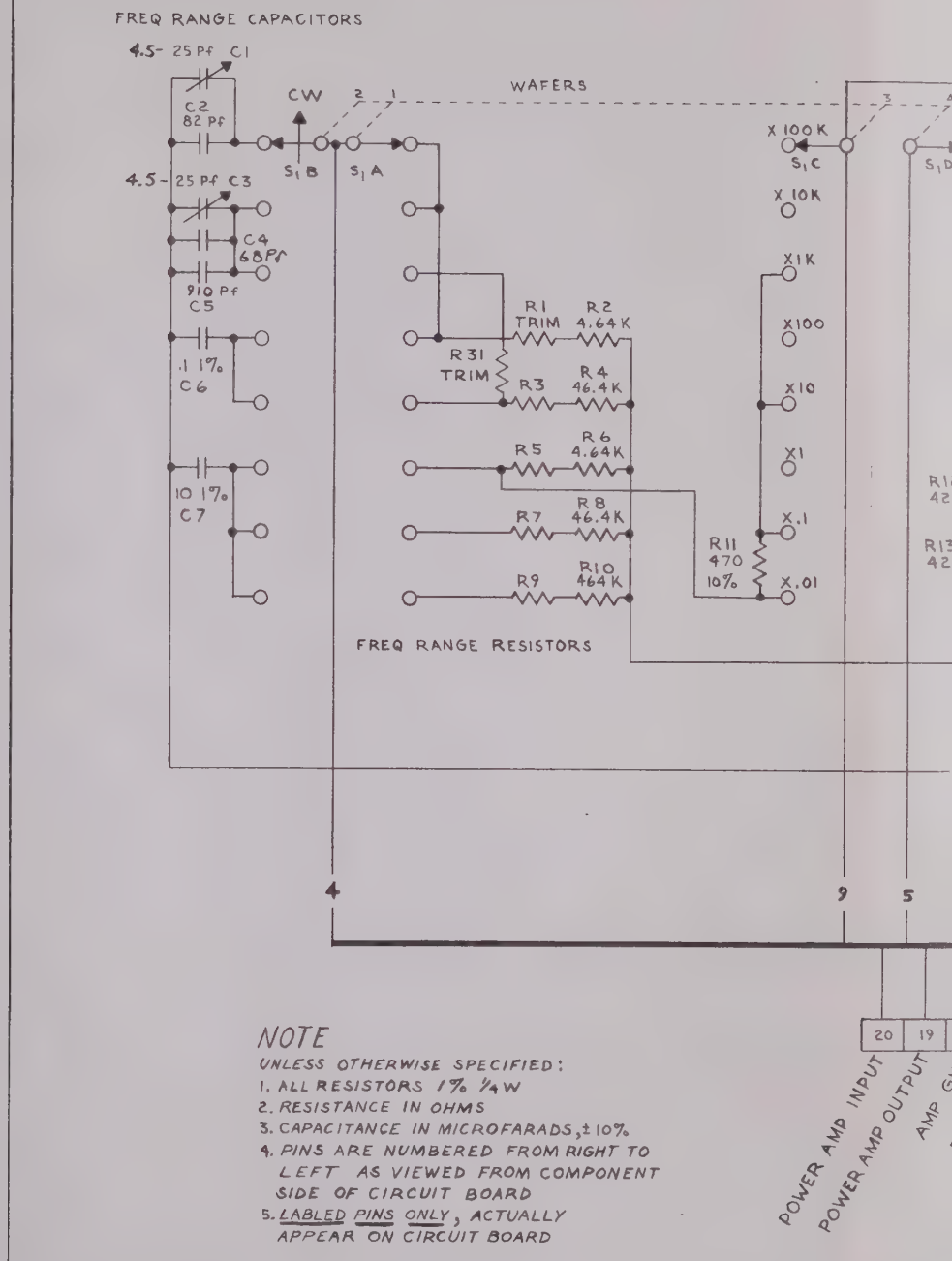
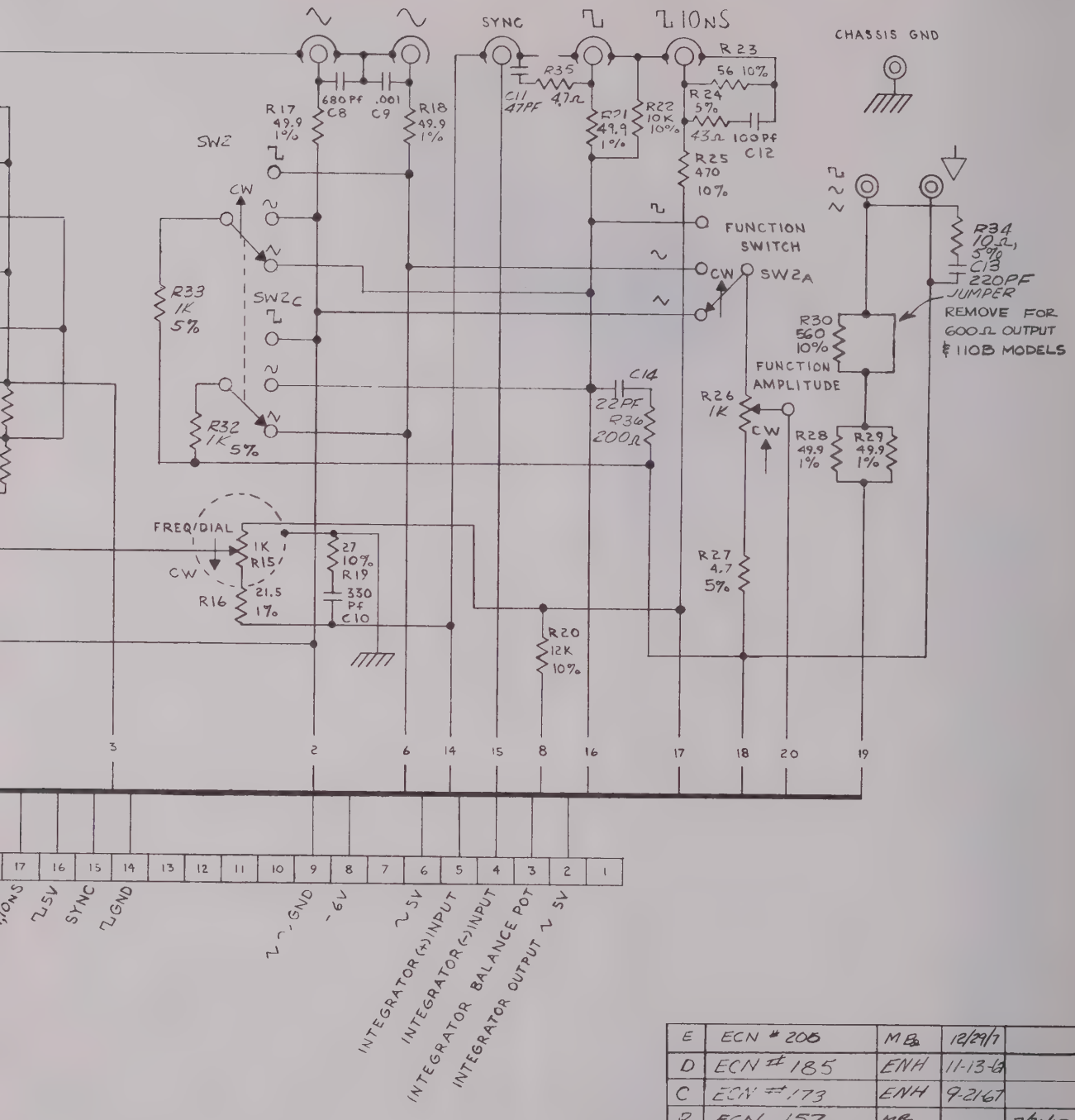


NOTE

UNLESS OTHERWISE SPECIFIED:

1. ALL RESISTORS 1% ¼W
2. RESISTANCE IN OHMS
3. CAPACITANCE IN MICROFARADS, ± 10%
4. PINS ARE NUMBERED FROM RIGHT TO LEFT AS VIEWED FROM COMPONENT SIDE OF CIRCUIT BOARD
5. LABLED PINS ONLY, ACTUALLY APPEAR ON CIRCUIT BOARD



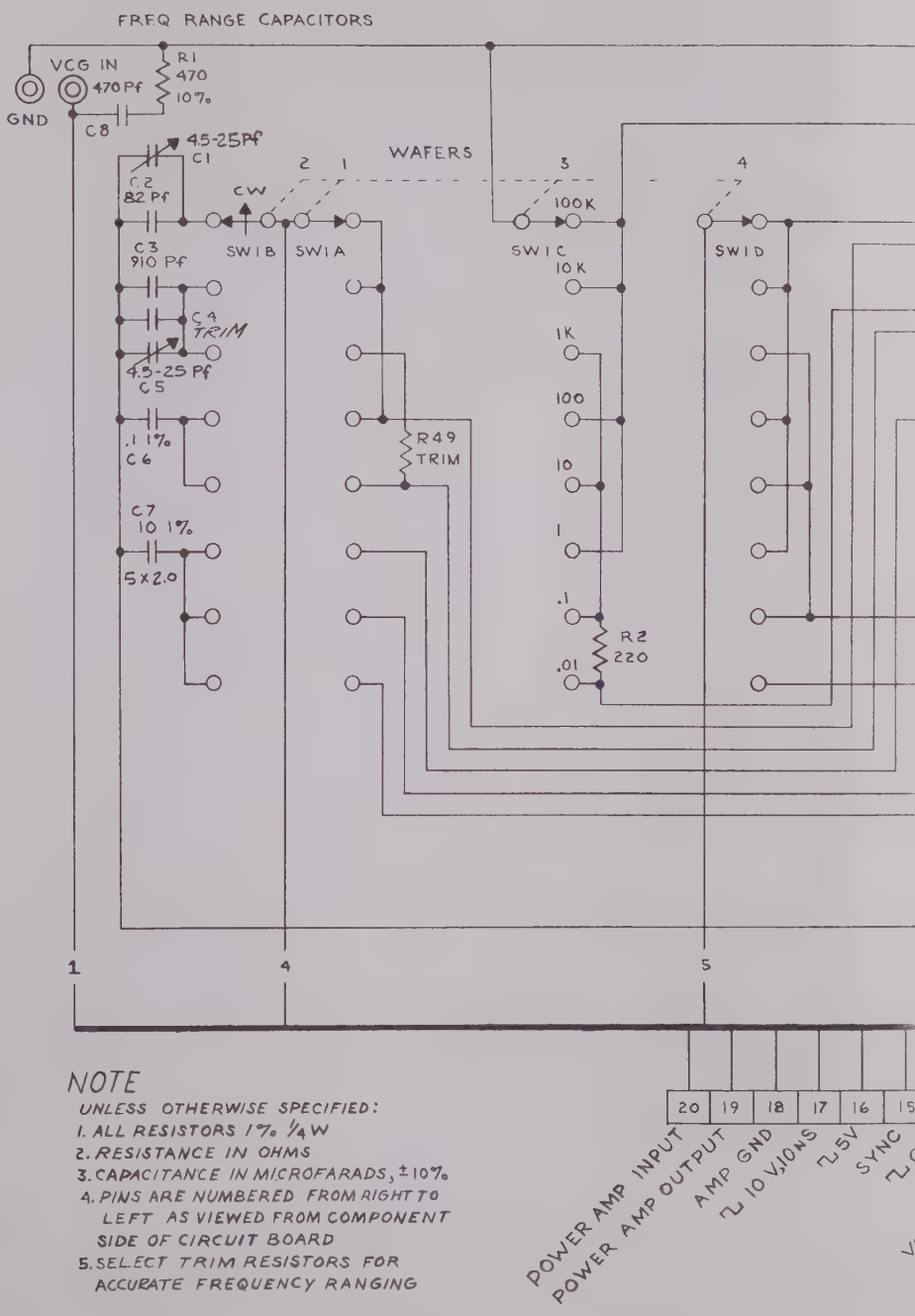
E	ECN # 205	MB	12/29/67	
D	ECN # 185	ENH	11-13-67	
C	ECN # 173	ENH	9-21-67	
B	ECN 157	MB		7/20/67
A	ECN #94 (WAS DWG # 110-201C)			12-9-66

WAVETEK
8159 ENGINEER RD
SAN DIEGO, CALIF

DRN PA Marsh DATE 1-19-66
APP: P. Mackie

FRONT PANEL

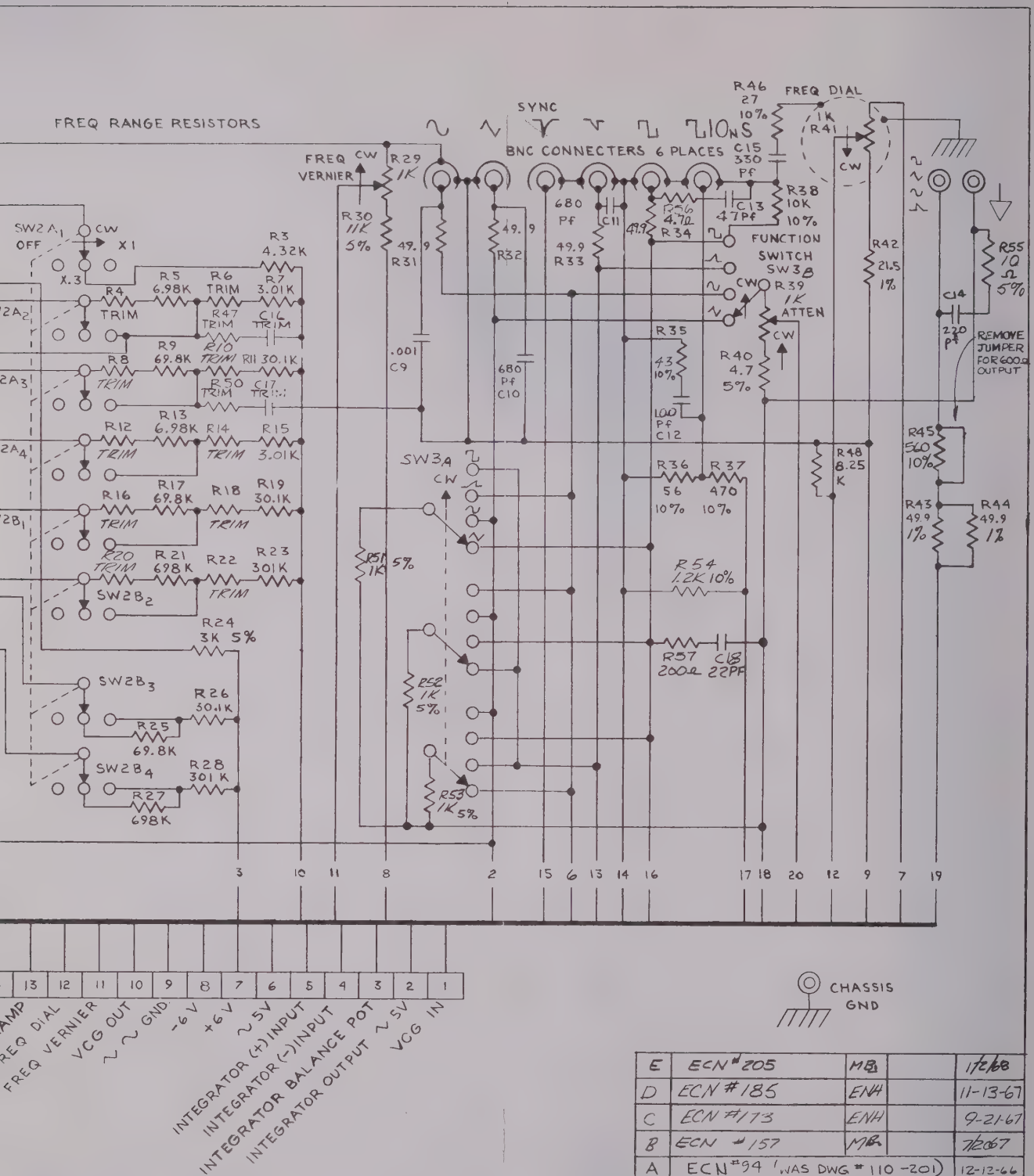
MODEL 110, 110B
NO 110-211E



NOTE

UNLESS OTHERWISE SPECIFIED:

1. ALL RESISTORS 1% 1/4 W
2. RESISTANCE IN OHMS
3. CAPACITANCE IN MICROFARADS, ±10%
4. PINS ARE NUMBERED FROM RIGHT TO LEFT AS VIEWED FROM COMPONENT SIDE OF CIRCUIT BOARD
5. SELECT TRIM RESISTORS FOR ACCURATE FREQUENCY RANGING



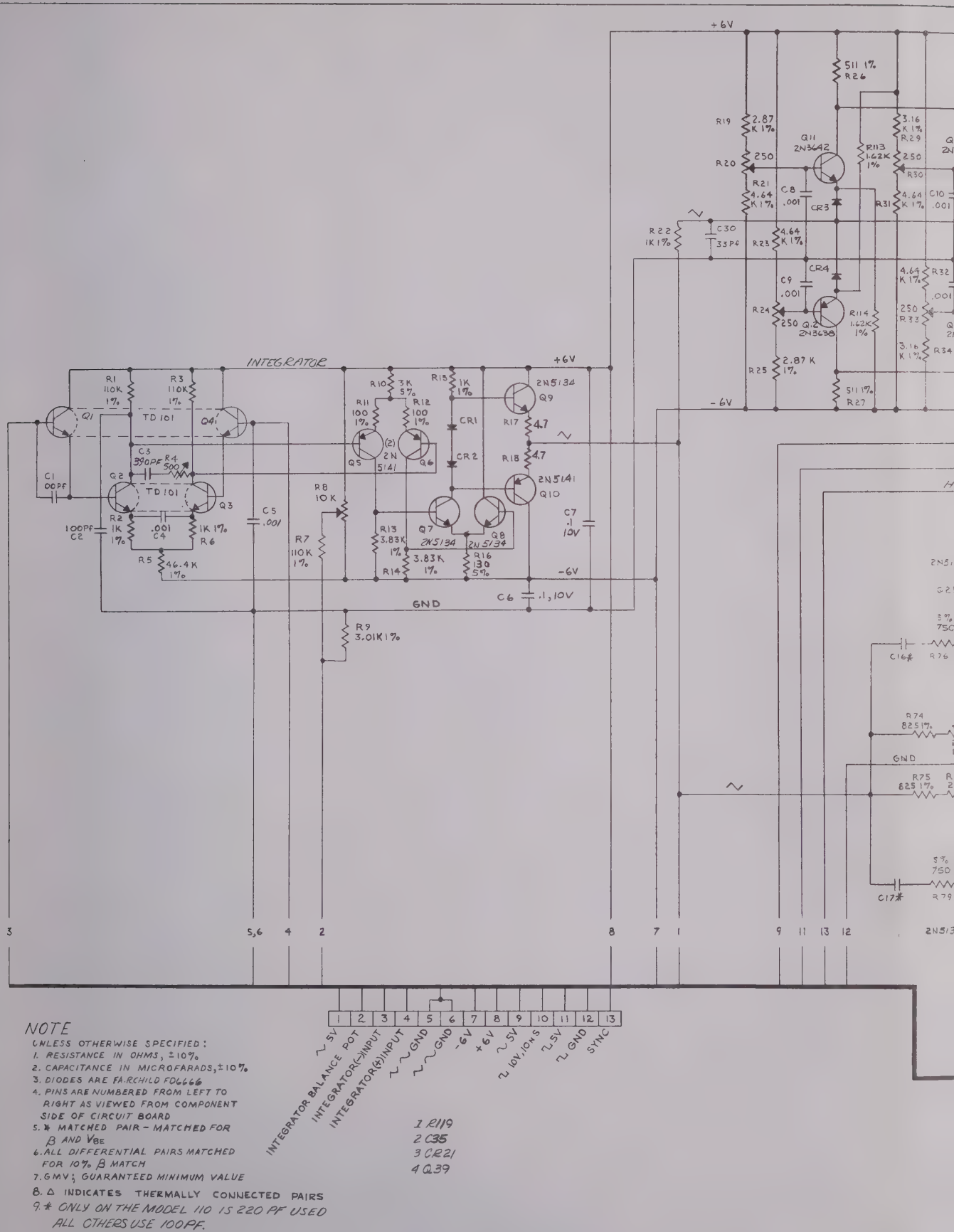
E	ECN #205	MB		1/12/68
D	ECN #185	ENH		11-13-67
C	ECN #173	ENH		9-21-67
B	ECN #157	MB		7/12/67
A	ECN #94 (WAS DWG # 110-201)			12-12-66

WAVETEK 8159 ENGINEER RD SAN DIEGO, CALIF

DRN PA March DATE 1-18-66 APP

FRONT PANEL

MODEL 111, 111B NO 111-217E

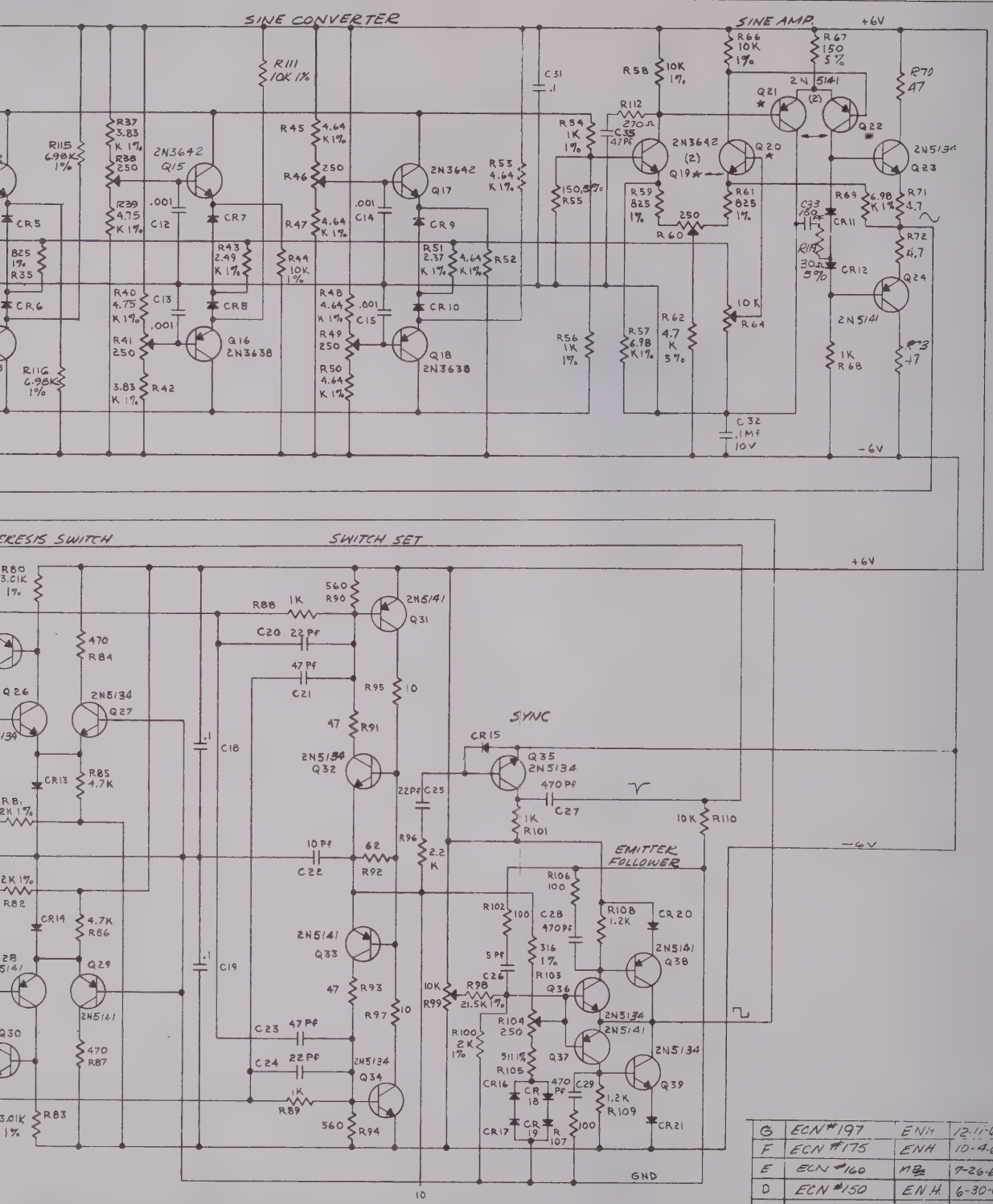


NOTE

UNLESS OTHERWISE SPECIFIED:

1. RESISTANCE IN OHMS, ±10%
2. CAPACITANCE IN MICROFARADS, ±10%
3. DIODES ARE FAIRCHILD FD6666
4. PINS ARE NUMBERED FROM LEFT TO RIGHT AS VIEWED FROM COMPONENT SIDE OF CIRCUIT BOARD
5. * MATCHED PAIR – MATCHED FOR β AND V_{BE}
6. ALL DIFFERENTIAL PAIRS MATCHED FOR 10% β MATCH
7. GMV; GUARANTEED MINIMUM VALUE
8. Δ INDICATES THERMALLY CONNECTED PAIRS
9. * ONLY ON THE MODEL 110 IS 220 PF USED ALL OTHERS USE 100PF.

1 R119
2 C35
3 CR21
4 Q39



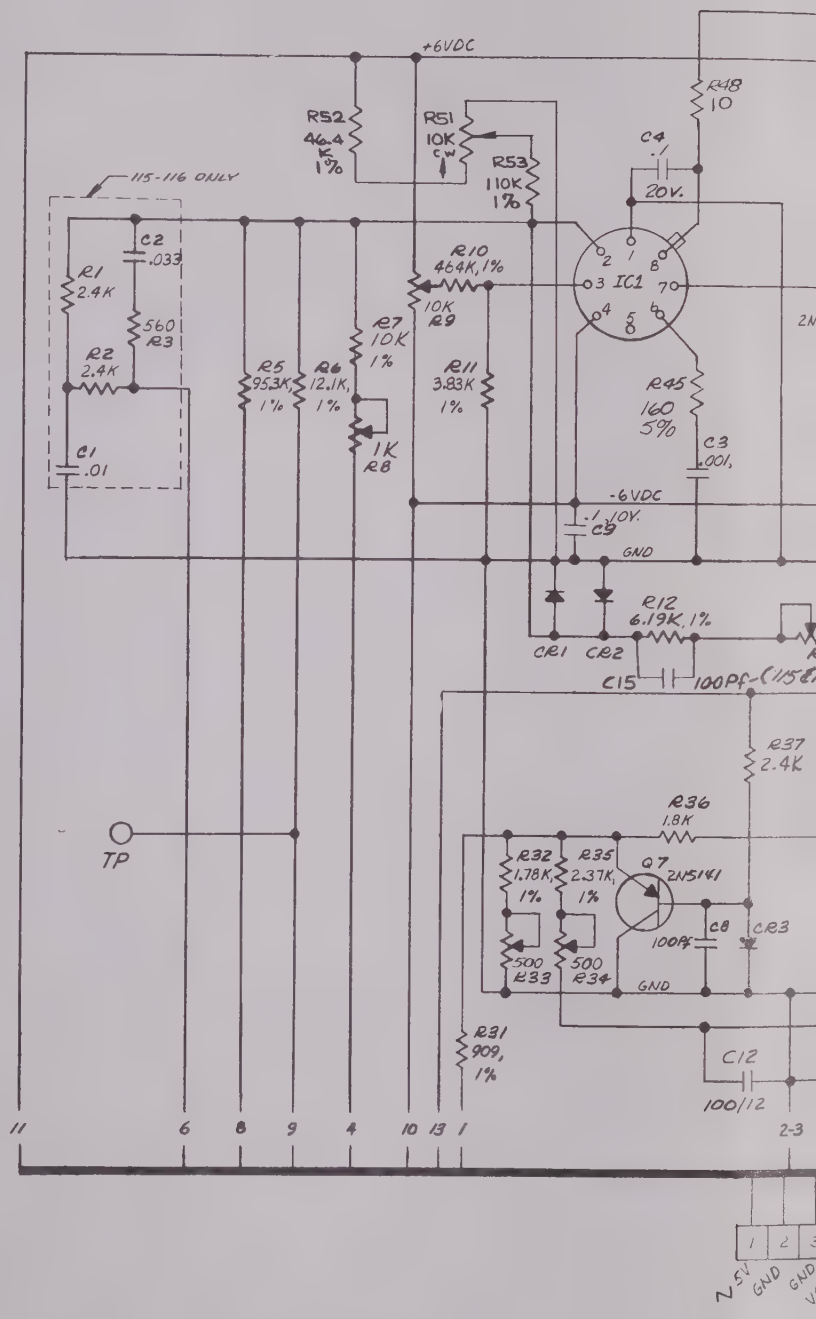
G	ECN #197	ENH	12-11-67	
F	ECN #175	ENH	10-4-67	
E	ECN #160	MB	7-26-67	
D	ECN #150	ENH	6-30-67	
C	ECN #147	MEB	6-21-67	
B	ECN #126	JW	3-27-67	
A	ECN #94 (WAS DWG # 110-202)	JW	12-12-66	
CHG	ECN NO	BY	DATE	APP

WAVETEK
8159 ENGINEER RD.
SAN DIEGO, CALIF

DRN: PA Marsh DATE: 1-14-66
APP: P Mackie

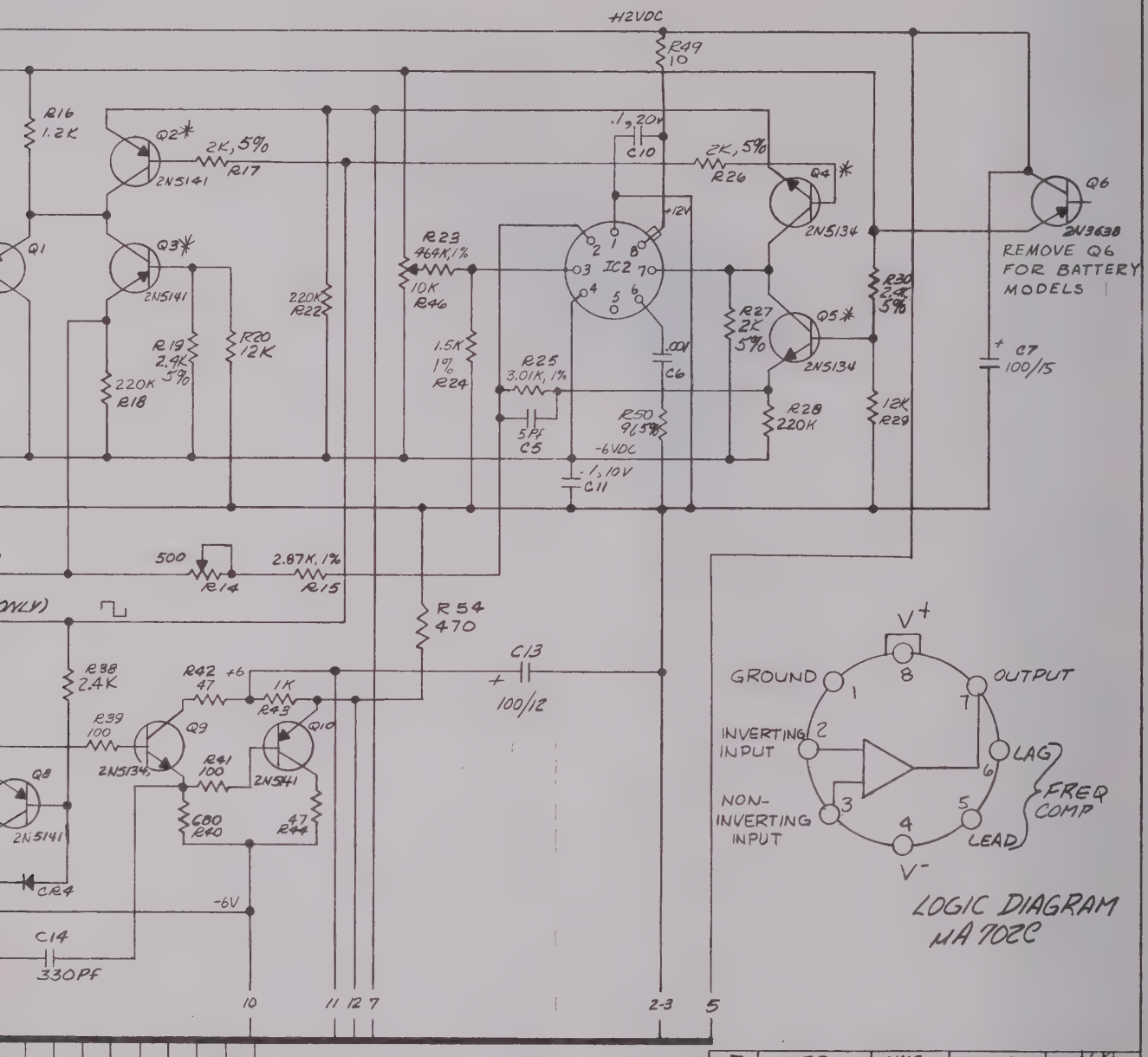
MAINBOARD SCHEMATIC

MODEL: 110, 110B, 111, 111B, 112, 112B, 115, 115B
NO. 110-2126



NOTES
UNLESS OTHERWISE SPECIFIED
1. RESISTANCE IN OHMS, 1/2 W, 10%, CARBON
2. CAPACITANCE IN MICROFARADS
3. DIODES ARE FAIRCHILD FD6666
4. INTEGRATED CIRCUITS ARE FAIRCHILD μA702C
5. * MUST BE MATCHED SPECIAL AS INVERTED SWITCHES.

1. R54
2. C16
3. CR4
4. Q10
5. IC2



E	139	DHE	5-15-67	DJP
D	134	PCM	4-11-67	DJP
C	127&128	JW	3/10/67	DJP
B	123	JW	2-13-67	DJP
A	116	JW	1-23-67	DJP
CHNG	ECN	BY	DATE	APP'D

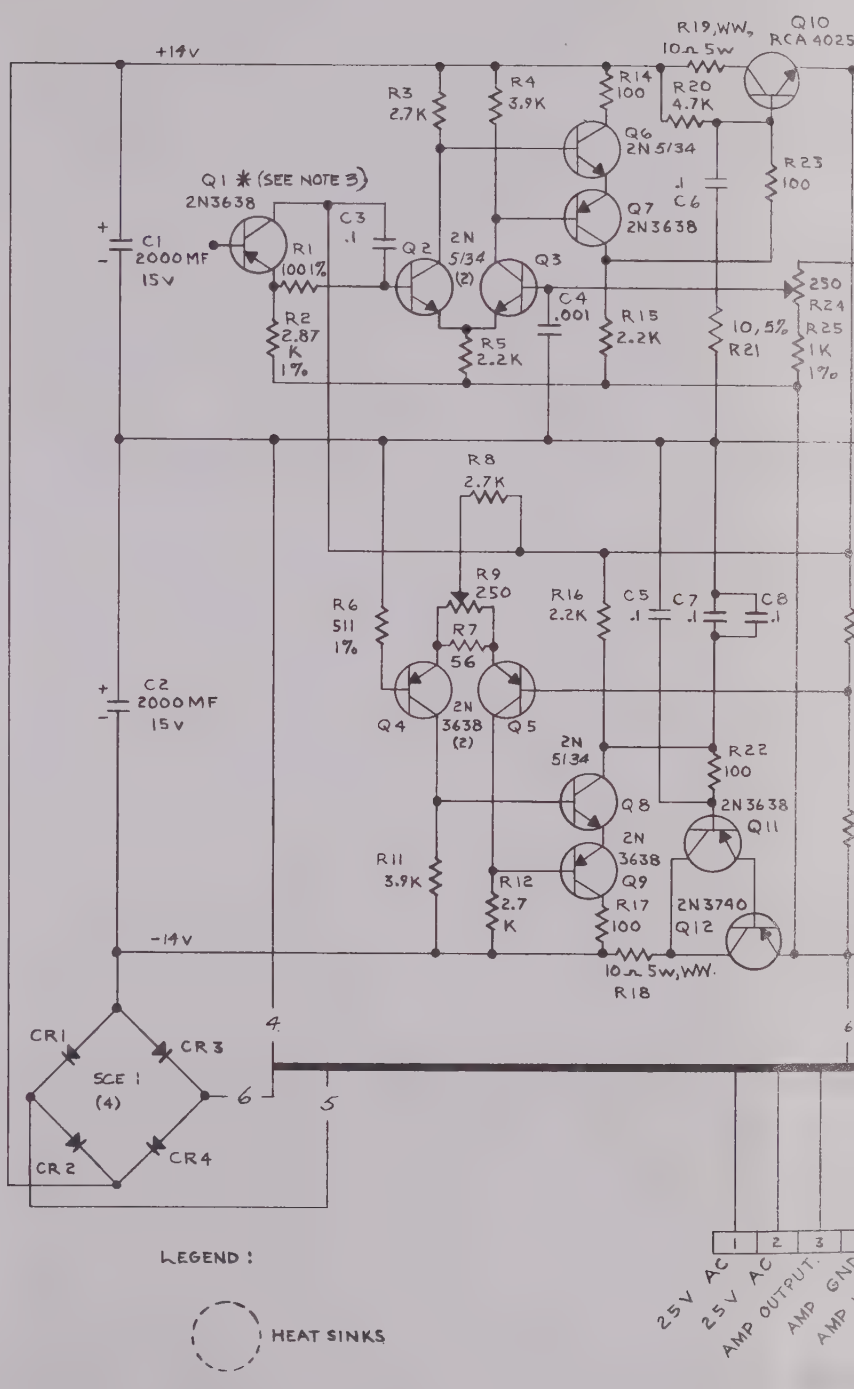
L	ECN 202	MB	12/26/7	
K	ECN#196	ENH	12-8-67	
J	ECN 161+162	ENH	7-26-67	
H	ECN #160	DHE	7-26-67	
G	ECN #156	MB	7/18/67	
F	ECN #150	ENH	6-30-67	
CHNG	ECN	BY	DATE	APP'D

WAVETEK
8159 ENGINEER ROAD
SAN DIEGO, CALIF.

DRN S.L.B. DATE 11-4-66 APP. P. Mackie

VCG SCHEMATIC

MODEL: 111, 112, , 115, 116 NO 111-218 L



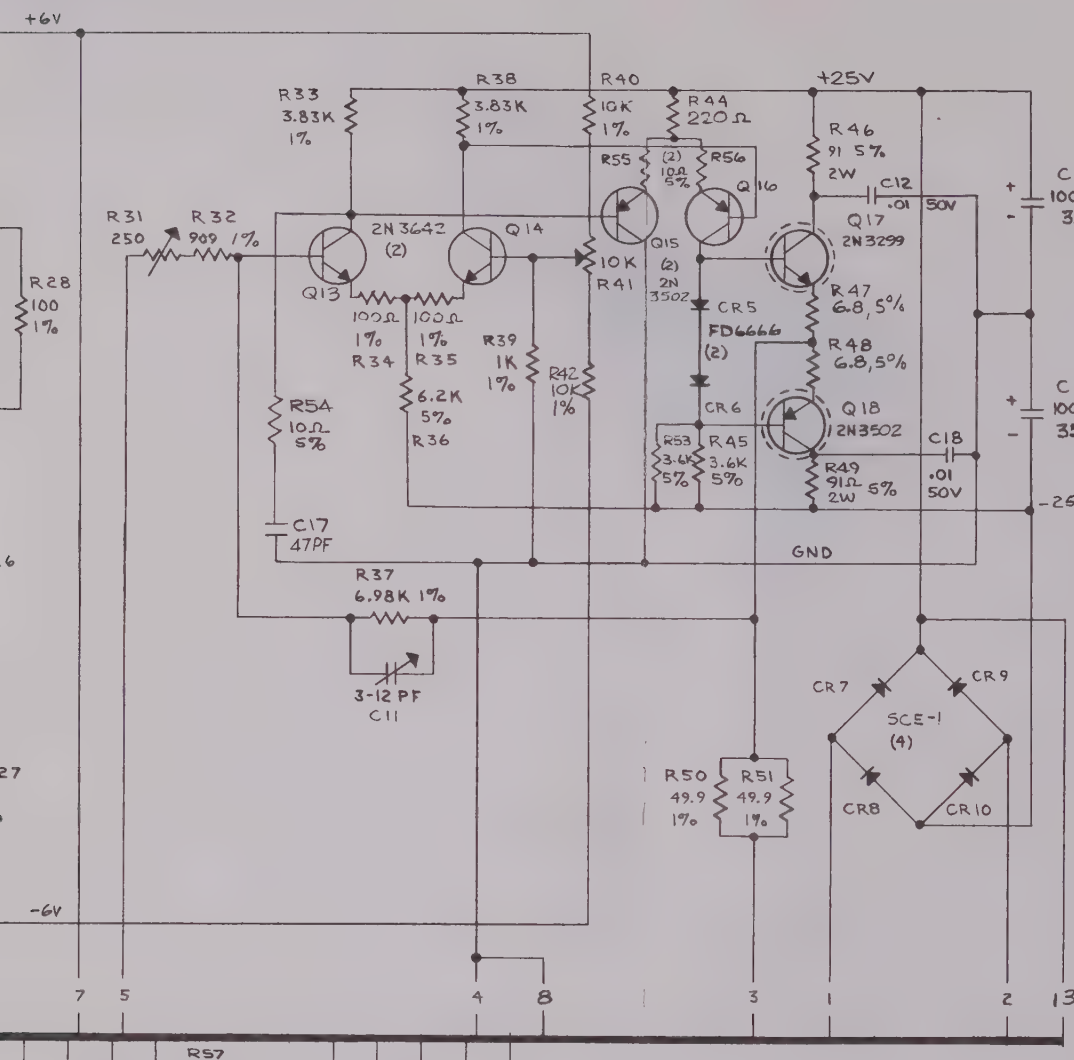
LEGEND :

HEAT SINKS

NOTE

UNLESS OTHERWISE SPECIFIED :

1. RESISTANCE IN OHMS, ±10%
2. CAPACITANCE IN MICROFARADS, ±10%
3. *Q1 PRE-SELECTED FOR ZENER VOLTAGE OF 6.6V ± .3V.
4. PINS ARE NUMBERED FROM LEFT TO RIGHT AS VIEWED FROM COMPONENT SIDE OF CIRCUIT BOARD
5. ALL DIFFERENTIAL PAIRS MATCHED FOR 10% β MATCH



CHG	ECN NO.	BY	DATE	APP
F	ECN #166	[illegible]	9/18/67	
E	ECN 157, 158	MB	7/20/67	
D	ECN #141	[illegible]	5-18-67	
C	ECN #136	[illegible]	5-1-67	
B	ECN# 131	JW	3-31-67	
A	ECN# 94	JW	12-12-66	

WAVETEK
8159 ENGINEER RD
SAN DIEGO, CALIF

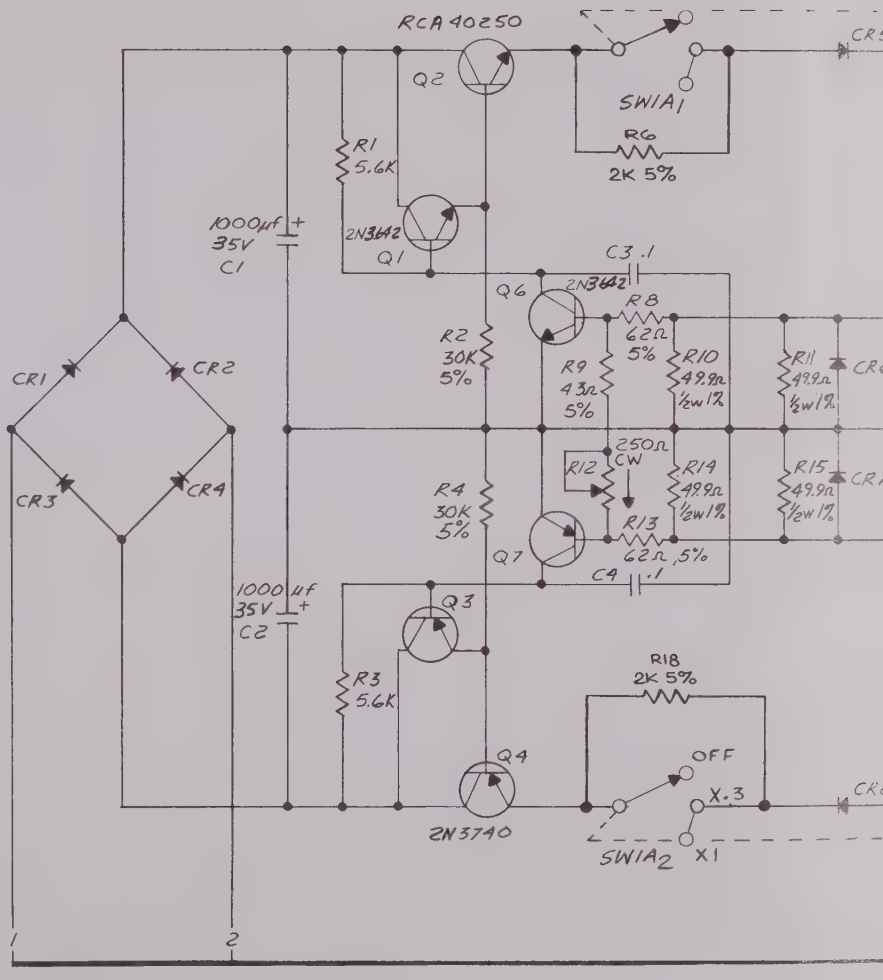
DRN DATE
PA Marsh 1-21-66

APP
P. Macchia

POWER SUPPLY AND OUTPUT AMP

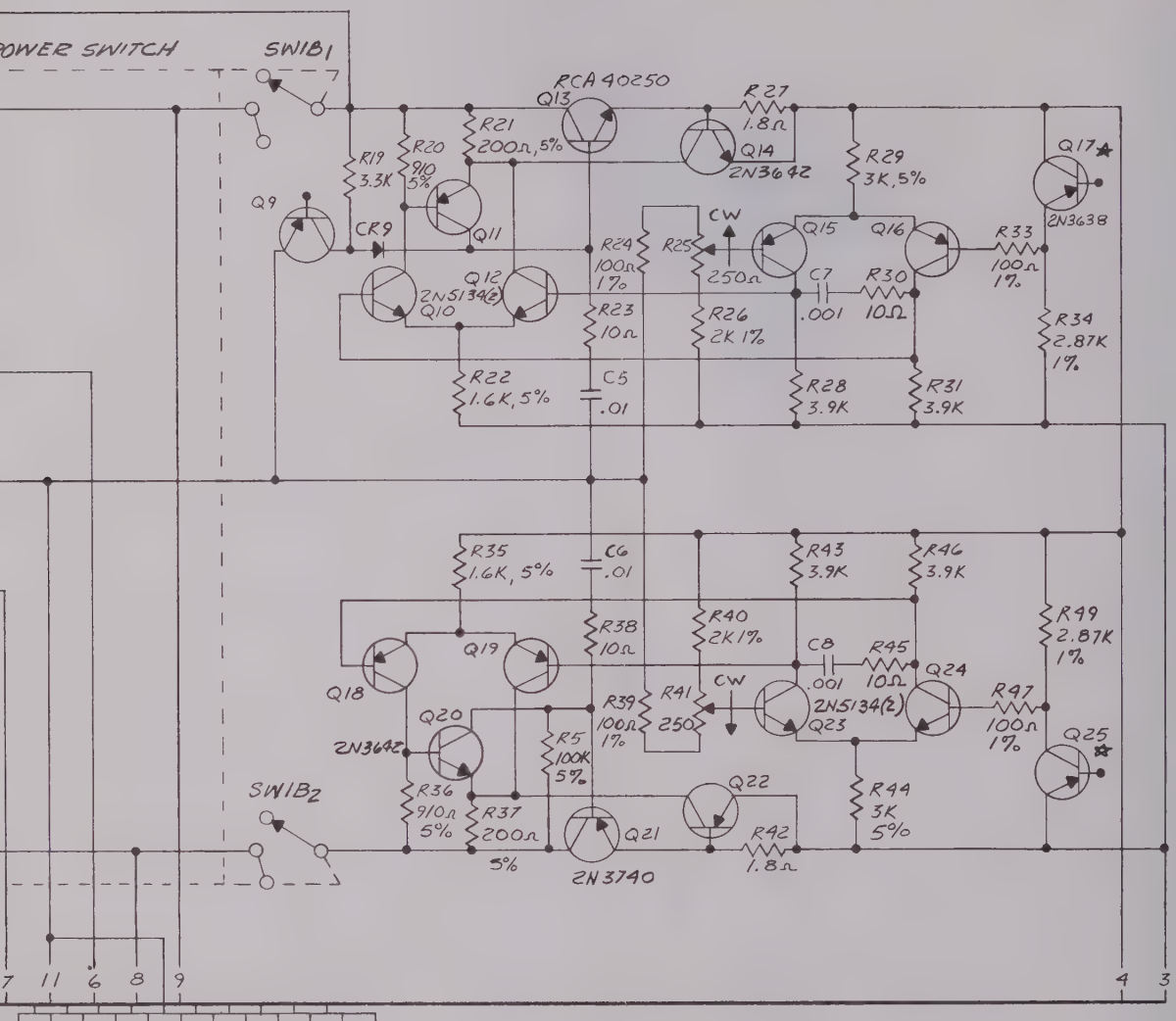
MODEL
110 THRU 116

NO
110-213 F



NOTE: UNLESS OTHERWISE SPECIFIED

1. ALL TRANSISTORS ARE 2N3638
2. ALL RESISTANCE IN OHMS, 1/2W, 10%
3. CAPACITANCE IN MICROFARADS
4. DIODES ARE SCE-1's.
5. PINS NUMBERED LEFT TO RIGHT AS VIEWED FROM COMPONENT SIDE OF BOARD.
6. ALL DIFFERENTIAL PAIRS ARE MATCHED FOR β
7. ★ INDICATES CHOSEN FOR 6.6V ±.3V ZENER VOLTAGE



LATEST COMP DESIGNATOR
R49
C 8
CR 8
Q25

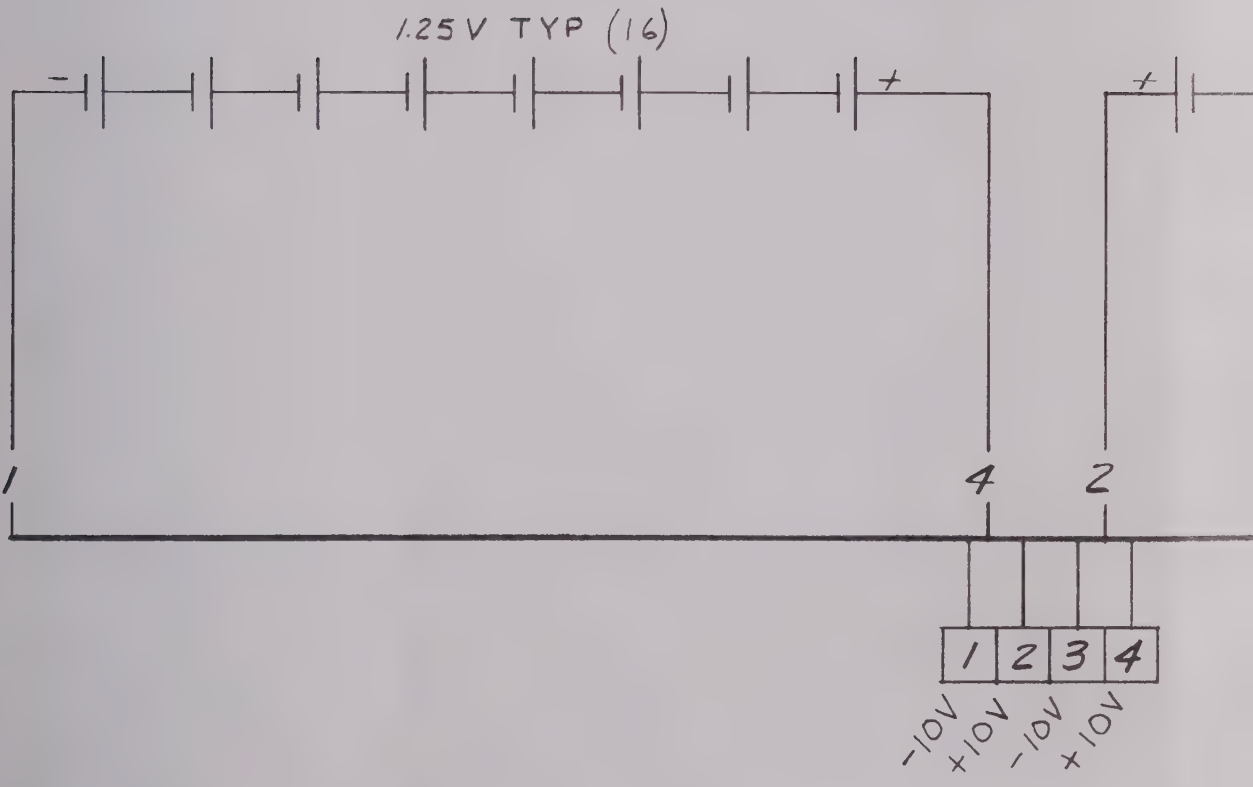
D	ECN #167	ENH	9-5-67	
C	153	MB	7/18/67	
B	ECN # 152	[illegible]	7/11/67	
A	94 (MAS DWG 1128-105)	JW	1-5-67	
CHANGE	ECN NO.	BY	DATE	APP'D

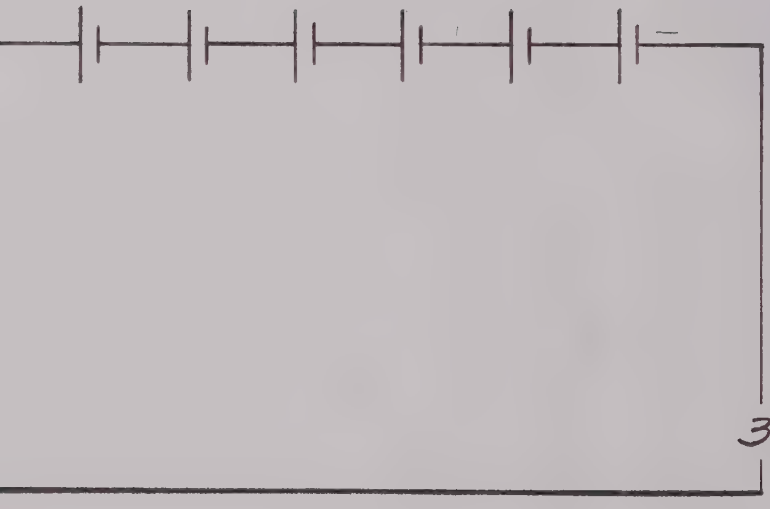
WAVETEK
8159 ENGINEER RD
SAN DIEGO, CALIF

DRN	DATE	APP
PA Marsh	7-21-66	P. Mackie

BATTERY REGULATOR BD

MODELS	NO
112-119-115-116	112-222D

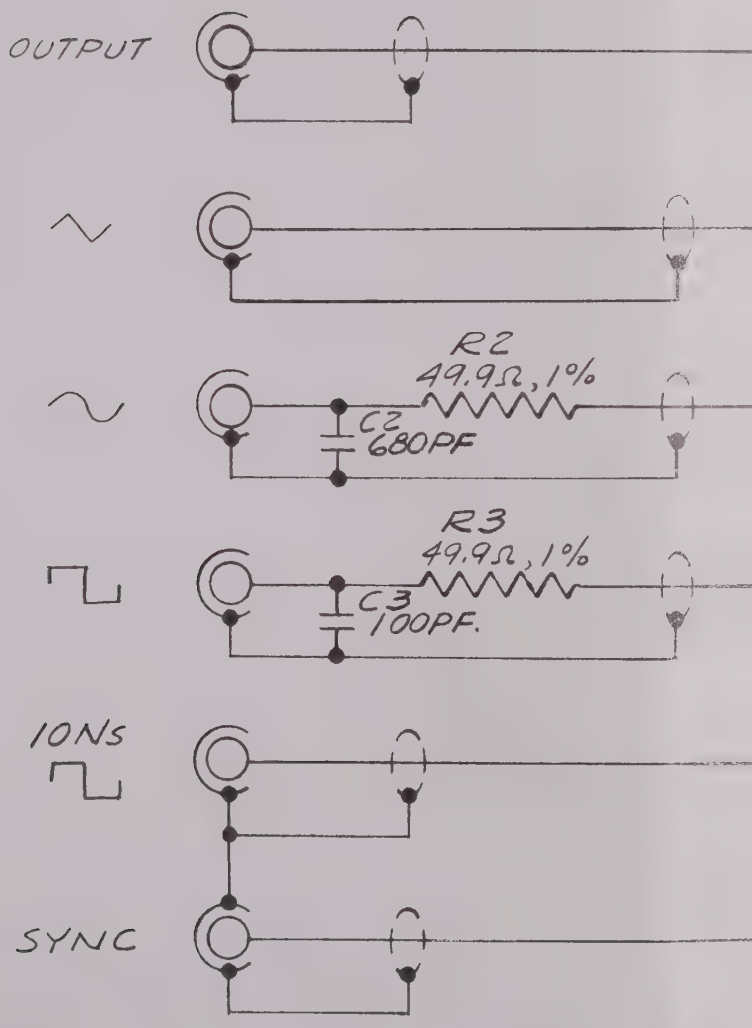

1.25V TYP (16)
-
+
+
1
4
2
1
2
3
4
-10V
+10V
-10V
+10V

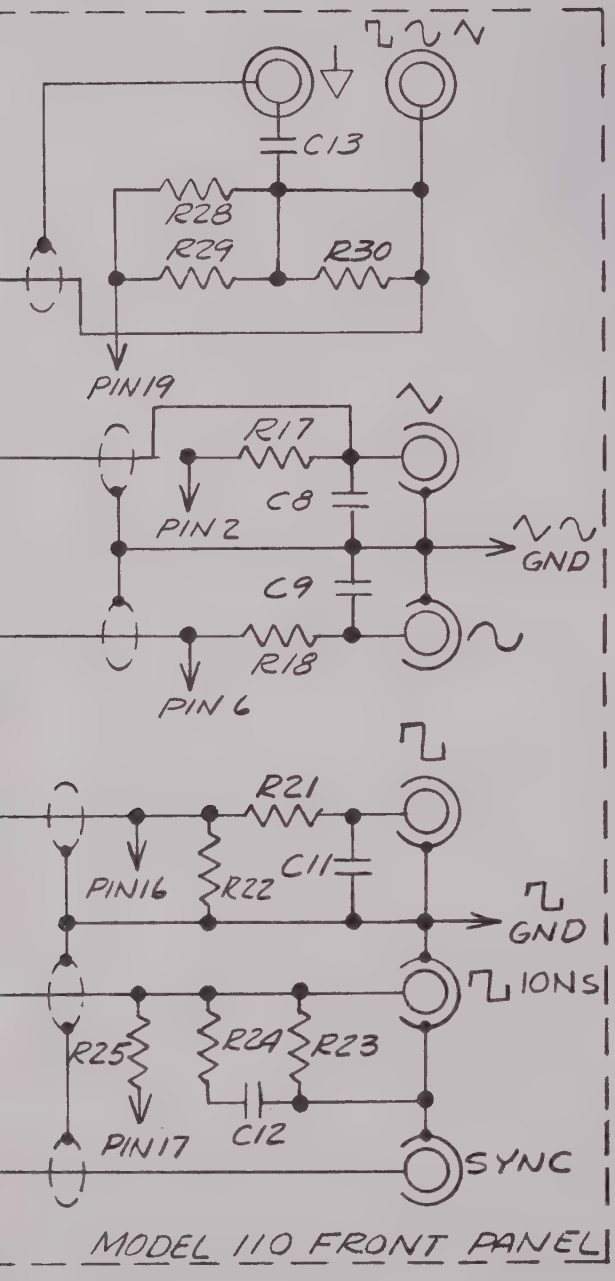


WAVETEK	8159 ENGINEER RD SAN DIEGO, CALIF.
DWN: WHITELOCK DATE: 1-16-67	APP'D:

SCHEMATIC - BATTERY PACK

MODEL: 112-116	NO.: 112-223

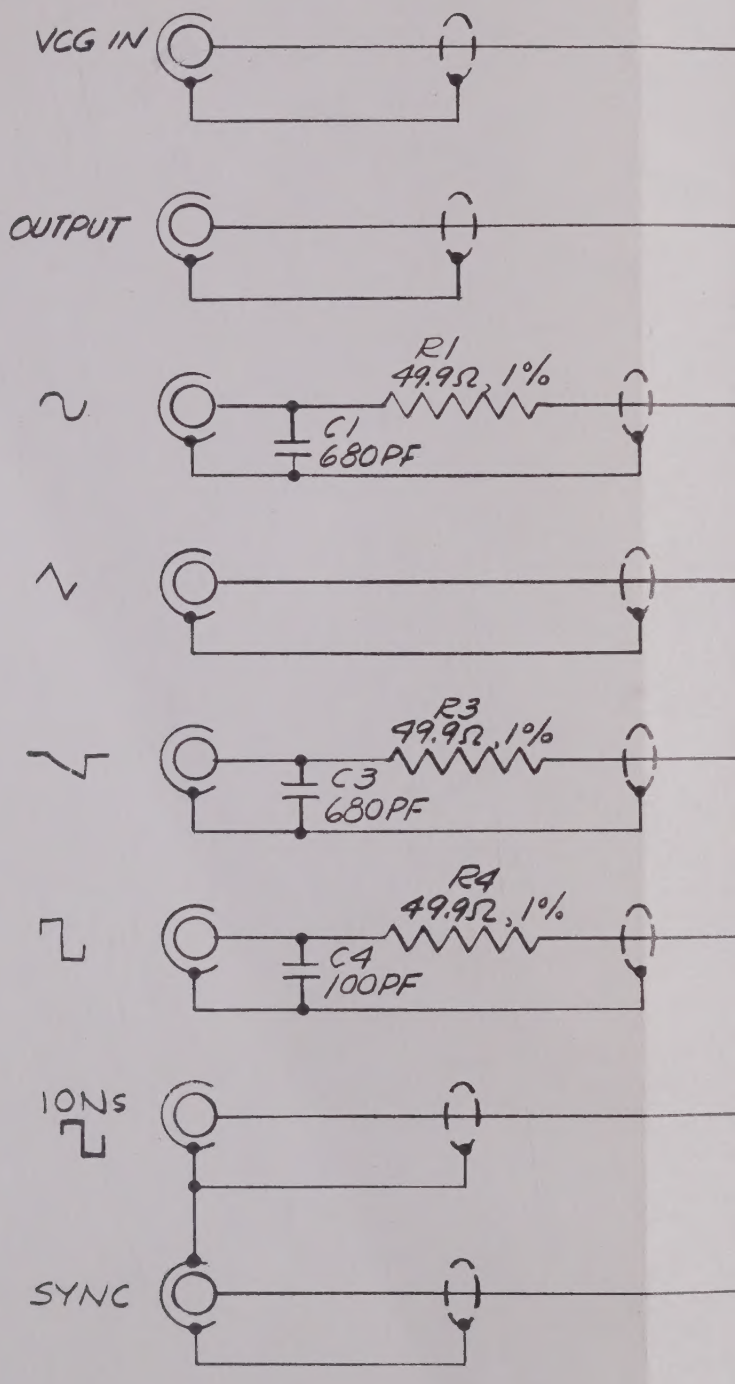

OUTPUT
R2
49.9Ω, 1%
C2
680PF
R3
49.9Ω, 1%
C3
100PF.
10NS
SYNC

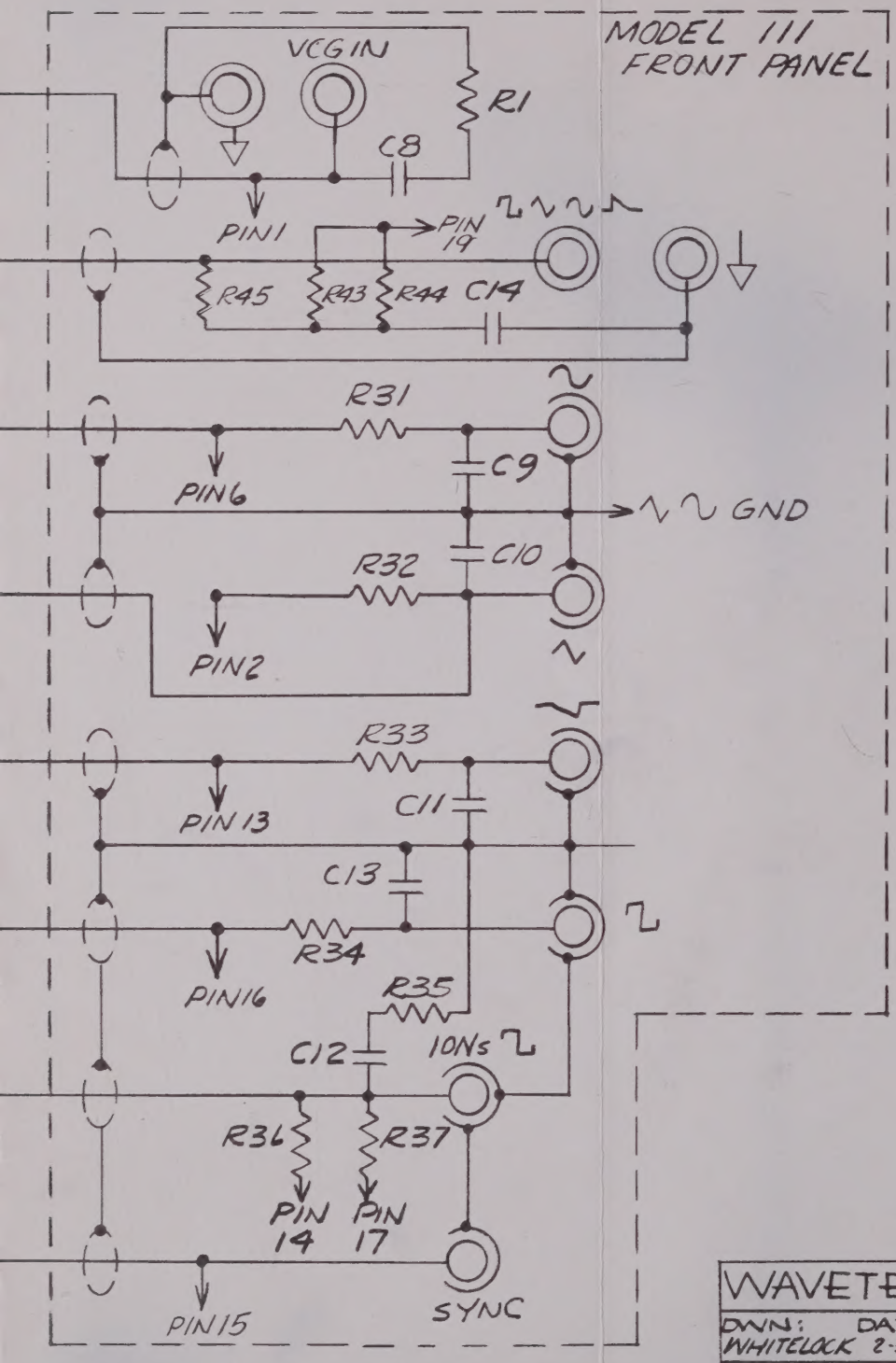


WAVETEK	8159 ENGINEER RD SAN DIEGO, CALIF
DWN: DATE: WHITELOCK 2-3-67	APP'D:

SCHEMATIC- CONNECTOR MTG. BOARD

MODEL: 110 RACK MOUNT	NO: 110-238


VCG IN
OUTPUT
R1
49.9Ω, 1%
C1
680PF
R3
49.9Ω, 1%
C3
680PF
R4
49.9Ω, 1%
C4
100PF
10Ns
SYNC



WAVETEK	8159 ENGINEER RD. SAN DIEGO, CALIF.	
DWN: WHITELOCK DATE: 2-3-67	APP'D: I. Wachs	
SCHEMATIC – CONNECTOR MTG. BOARD		
MODEL: 111 RACK MOUNT	NO: 111-237	

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